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ABSTRACT

Technological literacy--computer skills and the ability to use computers and other technology to improve learning, productivity, and performance--has become as fundamental to a person's ability to navigate through society as traditional skills like reading, writing, and arithmetic. The Technology Literacy Challenge, envisioning a 21st century where all students are technologically literate, requires the fulfillment of four main goals: (1) all teachers in the nation will have the training and support necessary to help students learn to use computers and the information superhighway; (2) all teachers and students will have modern multimedia computers in their classrooms; (3) every classroom will be connected to the information superhighway; and (4) effective software and on-line learning resources will be an integral part of every school's curriculum. A partnership between the private sector, state government, local communities, and the federal government is necessary to achieve these goals. This report presents a framework that states and local communities can use in developing local plans of action that will support the use of technology in achieving high standards of teaching and learning in all classrooms for all students. The report includes sections on: Technology Literacy: A National Priority; Benefits of Technology Use; Reaching the Technology Goals; and Roles Supporting Local Action Plans. Appendices include: background information on how this plan was developed; a list of sources of federal support for technology in education, a state-by-state breakdown of state support for technology in education; and a list of sources for further information. (Contains 106 references.) (SWC)

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Letter from the Secretary 3
Executive Summary 5
Technology Literacy: A National Priority 9
Background 9
The Technology Literacy Challenge 10
The Technology Goals 10
An Investment in the Future 11
Benefits of Technology Use 15
Enhanced Student Achievement 16
Basic Skills Instruction 16
Advanced Skills Instruction 18
Assessment of Student Progress 19
Student Motivation 20
Increased Family Involvement 20
Improved Teachers' Skills 21
Improved School Administration and Management 22
Characteristics of Successful Technology-Rich Schools 22
Conclusion 25
Reaching the Technology Goals 27
Progress Report 27
Cost of Meeting the Four Goals 32
Types of Costs 32
Cost Estimates 33
Funding Challenges 34
No Community Left Behind 36
Roles Supporting Local Action Plans 39
Role of the Federal Government 39
Technology Literacy Challenge Fund 40
Affordable Connections 40
Improved Professional Development 40
Improved Educational Software 41
Continued Investment in Educational Technology 43
Effective Use of Technology by Major Education Programs 43
Clearinghouse for Good Ideas 43
State-of-the-Art Tools 44
Closing the Divide Between Technology "Haves" and "Have-Nots" 44
Monitoring Progress Towards Technology Goals 44
Role of States and Local Communities 44
Leadership and Planning 45
Ongoing Support for Teachers 45
Modern Multimedia Computers in the Classroom 47
Effective Educational Software and On-Line Learning Resources 47
Adequate Financial Support and Equitable Access 47
Role of Higher Education and Private and Nonprofit Sectors 48
Supporting Professional Development 48
Instructional Materials 48
Collaboration With Elementary and Secondary Schools 49
Research on the Use of Technology in Education 49
From Vision to Reality 50
Endnotes 51
Bibliography 53
Appendices 57
A. How This Plan Was Developed 58
B. Federal Support for Technology in Education 59
C. State Support for Technology in Education 60
D. Sources of Further Information 69

Meeting the Technology Literacy Challenge

A Report to the Nation on Technology and Education

United States Department of Education

Richard W. Riley
Secretary

Madeleine M. Kunin
Deputy Secretary

Marshall S. Smith
Under Secretary

Linda G. Roberts
Director, Office of Educational Technology

June 1996

Members of Congress:

Over the last decade, the use of technology in American life has exploded. Yet most schools are still unable to provide the powerful learning opportunities afforded by technology, placing our children at a competitive disadvantage in the new, international marketplace of jobs, commerce, and trade.

Computers are the "new basic" of American education, and the Internet is the blackboard of the future. But the future is here and now, and we cannot miss this opportunity to help all of our young people grow and thrive. I strongly believe that if we help all of our children to become technologically literate, we will give a generation of young people the skills they need to enter this new knowledge- and information-driven economy.

To achieve this end, and in response to the ***Improving America's Schools Act of 1994*** *(Public Law 103-382), I have prepared a national, long-range technology plan. At the heart of this plan is the President's Technology Literacy Challenge, which urges that the nation's students be technologically literate by early in the 21st century.*

Because of the vital significance of the technology challenge to America's future, we sought advice from many different parties: teachers, students, parents, administrators, employers, and experts on the cutting edge of the technology revolution. The accompanying plan distills and builds upon this advice, proposing actions for meeting the Technology Literacy Challenge. Although the federal government has an important role in helping to galvanize efforts, the challenge is a clarion call to local communities and states and to the private and nonprofit sectors from which leadership and initiative must come.

I invite Congress to join in this undertaking by initiating a five-year, $2-billion commitment to a Technology Literacy Challenge Fund. The fund will be aimed at helping states and local communities to create and implement their own plans for integrating technology into teaching and learning for the purpose of achieving excellence among our students. I look forward to working with you to make this outcome a reality.

Sincerely,

Richard W. Riley

Richard W. Riley
Secretary of Education

"We know, purely and simply, that every single child must have access to a must understand it, must have access to good and good teachers and to the Internet, so that every person will have the opportunity to make the most of his or her own life."

President Clinton

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EXECUTIVE SUMMARY

Background

Technological literacy — meaning computer skills and the ability to use computers and other technology to improve learning, productivity, and performance — has become as fundamental to a person's ability to navigate through society as traditional skills like reading, writing, and arithmetic. Yet, for the most part, these new technologies are not to be found in the nation's schools. Students make minimal use of new technologies for learning, typically employing them for only a few minutes a day. Indeed, the hard realities are that only 4 percent of schools have a computer for every five students (a ratio deemed adequate to allow regular use) and only 9 percent of classrooms are connected to the Internet. In schools with large concentrations of low-income students, the numbers are often even lower. Research and the experiences of schools in the forefront of the current "digital revolution," however, underscore the enormous learning opportunities available through technology.

The Technology Literacy Challenge

In explicit acknowledgment of the challenges facing the education community, on February 15, 1996, President Clinton and Vice President Gore announced the Technology Literacy Challenge, envisioning a 21st century where all students are technologically literate. The challenge was placed before the nation as a whole, with responsibility for its accomplishment shared by local communities, states, the private sector, educators, parents, the federal government, and others.

The challenge, however, is more than a vision. At its heart are four concrete goals that help to define the task at hand:

- All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway.

  Upgrading teacher training is key to integrating technology into the classroom and to increasing student learning.

- All teachers and students will have modern multimedia computers in their classrooms.

  Computers become effective instructional tools only if they are readily accessible by students and teachers.

- Every classroom will be connected to the information superhighway.

  Connections to networks, especially the Internet, multiply the power and usefulness of computers as learning tools by putting the best libraries, museums, and other research and cultural resources at our students' and teachers' fingertips.

- Effective software and on-line learning resources will be an integral part of every school's curriculum.

  Software and on-line learning resources can increase students' learning opportunities, but they must be high quality, engaging, and directly related to the school's curriculum.

Investing in the Challenge: Meeting the Cost

Many components add to the cost of getting up-to-date technology and training into classrooms across America. Among the most obvious are hardware and software costs; connections within schools and to the Internet; the initial training and long-term support of teachers; and infrastructure improvements (such as

increased electrical capacity). The difficulty, however, is arriving at reliable estimates of what it will cost to meet all four goals. One reason for this difficulty is determining how schools should ultimately be outfitted. Another difficulty is the varied levels of technology currently found in schools around the nation. Yet another reason is that the technology itself is rapidly evolving.

Despite such complex variables, some organizations have produced estimates based on various models and assumptions. One estimate puts the cost at $109 billion over 10 years, or an average of $11 billion a year, taking into account both initial investments and ongoing expenditures. Another estimate puts the cost at between $10 billion and $20 billion a year over a five-year period. Yet another puts the cost at between $10 billion and $12 billion a year over five years. To put this into perspective, schools spent about $3.3 billion on technology during the 1994-95 school year.

The conclusion that leaps from these numbers is that schools alone cannot meet their need. It will take a partnership of the private sector, states and local communities, and the federal government to shoulder the financial burden of meeting these goals. Additionally, it will take careful planning to make certain that, in our reach for technological literacy, schools in all types of communities — middle-income, lower-income, and better-off communities — have access to up-to-date technology in their classrooms.

What We All Can Do to Meet the Challenge

The nation already has taken steps to integrate technology into schools, but what remains to be done looms large. While acknowledging the federal government's leadership role, the purpose of this report is to present a framework that states and local communities can use in developing local plans of action that will support the use of technology in achieving high standards of teaching and learning in all classrooms for all students. It will take contributions from all sectors of society to get America's students ready for the 21st century.

Federal Role

The federal government's role is to provide the momentum to support state and local efforts to meet the Technology Literacy Challenge. This is done through leadership, targeted funding, and support for activities that will catalyze national action. Building on current educational technology activities, the president proposed the Technology Literacy Challenge Fund. Making $2 billion available over five years, the fund would spur states, local communities, and other involved parties to step forward, produce matching dollars and in-kind contributions, and cooperate with one another in attaining the four goals. Additionally, in its leadership capacity, the federal government will continue to promote affordable connections, to support professional development, and to conduct research and development.

State and Local Community Roles

Appropriately, a number of states and local communities have been the leaders in moving schools toward an increased use of technology for learning. States and communities can continue to take the lead in developing action plans based on their own priorities. They can distribute funds based on the needs of individual districts to promote equity among schools, and use existing educational funds in new ways. They can invest in technological infrastructure to connect schools to networks. And they can make a concerted effort to build community support.

Higher Education and Private and Nonprofit Sector Roles

Institutions of higher education, businesses, foundations, and other organizations will need to shoulder a large share of the effort to integrate technology into schools. And the push is already on. Collectively, businesses have developed technology specifically for the education market and have donated millions of dollars of resources to schools. Colleges and universities across the country are training teachers in the effective use of technology. Still, these kinds of efforts will have to be magnified many times over for the vision of technological literacy to be realized.

The school has offered things to students, my son included, which I never dreamed possible. The students use computers to perform homework, to explore new avenues — the academic program here is unparalleled due to technology and the dedication of the staff.

— Parent, Presentation to President Clinton

Conclusion

As advances in technology race ahead, we must ensure that the nation's students become technologically literate. Not to meet this challenge will mean that American students will only fall further and further behind. With reading, writing, and arithmetic, technology has become the nation's "new basic." Our children's future, the future economic health of the nation, and the competence of America's future workforce depend on our meeting this challenge.

"Our country was built on a simple value that we have an obligation to pass better lives and better opportunities on to the next generation. Education is the way we make that promise real. Today, at the dawn of a new century, in the mids of an

depends upon computers

If we make an opportunity for every student, a fact in the world of modems and megabytes, we can go a long way toward making the American Dream a reality for every Not virtual reality — reality for every student"

President Clinton

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TECHNOLOGICAL LITERACY:

A NATIONAL PRIORITY

Background

The march of human progress has been marked by milestones in science and technology. Gutenberg's creation of moveable type in the 15th century laid the foundation for universal literacy. Watts's invention of the steam engine in the 18th century launched the Industrial Revolution. The inventiveness of Bell and Marconi in the 19th and 20th centuries — creating the telephone and radio — helped bring a global village into being.

The United States and the world are now in the midst of an economic and social revolution every bit as sweeping as any that has gone before: computers and information technologies are transforming nearly every aspect of American life. They are changing the way Americans work and play, increasing productivity, and creating entirely new ways of doing things. Every major U.S. industry has begun to rely heavily on computers and telecommunications to do its work.

But so far, America's schools have been an exception to this information revolution.* Computers and information technologies are not part of the way most American students learn. Today's students spend an average of only a few minutes a day using computers for learning. Only 4 percent of schools have a computer for every five students — a ratio sufficient to allow regular use.[1] Only 9 percent of classrooms have connections to the Internet.[2]

* This report focuses on the uses of technology in elementary and secondary education in order to improve student achievement. It does not address the very important, but distinct, issues of technology use in adult literacy, job training, and higher education. The Department intends to do further work in these areas in the future.

If classes aren't offered on how to use computers and technology to build skills and get jobs, it is a disgrace. Think of the future and all the skills our children will need.

— Parent, Southeast Regional Forum

The Technology Literacy Challenge

As the nation responds to this technological revolution, it also faces a major educational challenge. Our economy is characterized by rapidly changing technologies and increasing international economic competition. And, our society is complex, diverse, and mobile. Success as a nation will depend substantially on our students' ability to acquire the skills and knowledge necessary for high-technology work and informed citizenship.

We know that all students can achieve far more than they have been asked to in the past. The experiences of researchers, teachers, and students make that point clear. This is why there is strong interest among states and communities around the nation in setting new, high standards for what students should know and be able to do in the core academic subjects. In Delaware, for example, parents now know that their children will have to master an understanding of DNA in 12th-grade science. Similarly, in Colorado, parents of 4th graders now have a clear idea of what their children are expected to be able to read.

Nonetheless, evidence from research and the experience of leading-edge schools shows that without the opportunities afforded by technology our children's future is jeopardized. Properly used, technology increases students' learning opportunities, motivation, and achievement; it helps students to acquire skills that are rapidly becoming essential in the workplace; and it breaks the barriers of time and place, enabling students in any community, no matter how remote or impoverished, to have access to high-quality instruction.

The American people understand these realities clearly and have embraced technological literacy as the "new basic" for today's world, along with reading, writing, and arithmetic. Technological literacy is not just knowing how to use technology for word processing, spreadsheets, and Internet access. Fundamentally, it is using the powerful learning opportunities afforded by technology to increase learning in academic subjects and increase students' skills. Recognizing the importance of technological literacy, 80 percent of Americans feel teaching computer skills is "absolutely essential."[3] More than three-quarters have encouraged a child to use a computer, and 86 percent believe that a computer is the most beneficial and effective product they could buy to expand their children's opportunities.[4]

The Technology Goals

The president believes we must help America's learners be prepared to meet the challenges of the 21st century. In his State of the Union address in January 1996, he challenged the nation, saying "every classroom in America must be connected to the information superhighway with computers and good software and well-trained teachers."

To bring this about, he has set four goals for tech-

nology in schools designed to lead to technological literacy for students, based on what educators, business leaders, parents, and many others have identified as key priorities:

- All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway;
- All teachers and students will have modern multimedia computers in their classrooms;
- Every classroom will be connected to the information superhighway; and
- Effective software and on-line learning resources will be an integral part of every school's curriculum.

Achieving each of these goals, discussed in more detail later, will be essential to the future technological literacy of our nation's young people. Indeed, without trained and experienced teachers, we know that computer equipment sits idle in classrooms, unused. We know that without connections to the Internet, students cannot access on-line resources such as those provided by the Library of Congress. And we know that without high-quality software and well-trained teachers, computers alone do not help students meet challenging academic standards. Twenty-first-century schools will combine these elements to ensure that America's children meet the future with a wealth of opportunities.

An Investment in the Future

A newly wired nation with powerful digital capabilities has arrived with startling speed. Just two generations ago, computers were physically imposing but had modest capabilities. They often took up entire rooms and cost a small fortune. In the single decade of the 1980s, millions of personal computers made their appearance on desks and laps everywhere — in factories, offices, homes, universities, airplanes, and schools — accompanied by the facsimile machine and the mobile telephone. In fact, today's average personal computer is faster and more powerful than the room-sized computers of the 1970s. At the same time, a national information infrastructure capable of fully supporting this wired nation is being put into place.

Students who graduate in the next few years will go to work in businesses that use the global communications system. If they don't know how to use it, they will be at a severe disadvantage.

— Assistant Superintendent, Rancho Cordova, CA[3]

While the challenge to keep up with such change may seem daunting, *now* is the time to invest in the future of America's students. First, a growing body of research shows that use of technology in the classroom can increase student achievement significantly. Second, four decades of federal and private sector research and development have led to breakthroughs in hardware, network technology, and educational software design that make high-performance technology more accessible and affordable than ever before. And finally, those leading-edge communities that are now making massive investments in technology, infrastructure, software, and training for teachers are beginning to reap dramatic results, demonstrating the promise of bringing technology to all the nation's classrooms.

A concerted national effort will be required to meet this technology literacy challenge — an effort that will

CHRISTOPHER COLUMBUS MIDDLE SCHOOL

Union City, N.J.

Technology in Support of Reform

By the late 1980s, the Union City school district was on the verge of being taken over by the state. This densely populated, poor, urban school district with 60,000 residents packed within one square mile had difficulty meeting New Jersey state education goals. Student attendance and scores on standardized tests were below state averages, while dropout and transfer rates were far above the state norm.

All that began to change in the 1989-90 school year. A new district superintendent and a new executive director for academic programs were appointed, and, because of the district's poor academic track record, the state required Union City to develop a five-year restructuring plan.

At the same time district reforms were taking place, the school district extended feelers to business and industry in New Jersey, hoping to convince those communities to invest resources in the schools. Bell Atlantic — looking to test a communications system in an inner city, minority school district with a dense population — spotted the district's call for investment and decided that Union City was a match. The school district was renovating an old parochial school, Christopher Columbus, that it had recently purchased to house 7th- and 8th-graders from two elementary schools that were overcrowded. In 1992, Bell Atlantic approached the school district and offered to work with them to demonstrate how technology could be used to improve student performance. It was an offer the district could not refuse.

In the summer of 1993, Bell Atlantic installed in the school and homes of all 7th-grade students and their teachers 486-level computers equipped with graphics and voice capabilities. Users can communicate between school and home and have basic software tools to carry out curriculum activities. Students and teachers are encouraged to keep the computers over the summer, and the computers supplied by Bell Atlantic now supplement the ones already purchased by the school district. In addition to each classroom having several computers, there are computers in the media resource room, the science laboratory, and the computer laboratory — all areas to which students have access — and the teachers' room, too.

The results of these reforms have been impressive. On New Jersey's Early Warning Test, test scores for Christopher Columbus students in reading, math, and writing are now more than 10 points *above* the statewide average across the board. Christopher Columbus also holds the district's best attendance record for both students and faculty. The transfer rate has dropped significantly at Christopher Columbus. Parents who could not speak English just two years ago are now actively involved with their children's use of the computers at home and frequently send messages to teachers and the school principal. Students are using the media resource room during lunch time and after school. They're actually eager to hand in their homework, neatly typed on the computer. And they're lining up before the formal school day begins so that they can get into the building.

demand the determination and persistence of the entire nation. It is an enormous undertaking. As a part of its contribution, the Clinton administration has proposed to establish the Technology Literacy Challenge Fund, which would offer $2 billion over five years to help catalyze commitments from state governments, private companies, and community leaders. It has supported, and Congress has enacted, the Telecommunications Act of 1996, which makes it possible for schools and libraries to have affordable access to advanced telecommunications services. And it has championed on-going federal investments in key activities such as distance learning, use of technology in math and science education, and research and development of new, effective educational technology.

While the federal government has important contributions to make in its leadership role, it is state governments and local communities that have the most to contribute and the most at stake. Consequently, this report does not lay out a single, prescriptive course of action. Rather, the report provides a national strategic framework that outlines the limited but important federal role as well as ideas for how states and local communities can develop their own plans to use technology to increase student achievement.

This national technology plan focuses on how schools, communities, and states can apply today's sophisticated information technology to raise student achievement, with the aim of attaining new standards of educational excellence set by states and local communities. The remaining chapters of this plan discuss in more detail what Americans need to know to go forward with a clear understanding of the Technology Literacy Challenge: the promise of technology, how far we have to go to meet the technology goals, what investments are needed, and how we all can get involved.

Information about how this plan was developed can be found in Appendix A.

Can schools afford the investment? The real question is, can they afford not to make the investment?

— District Superintendent, Northwest Regional Forum

want what's

best for their and

parents now realize that education today

has to be than what was

provided for them"

Parent, Midwest Regional Forum

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Benefits of Technology

BENEFITS OF TECHNOLOGY USE

Educators have used computers and other information technologies as tools to increase student learning in America's elementary and secondary schools for over 30 years. The 1960s brought computer-assisted instruction (CAI) to schools. CAI was developed to help students acquire basic skills, practice them, and measure learning gains.

With the development and increased availability of lower-cost personal computers, the use of technology in schools broadened in the early 1980s to encompass the use of general-purpose tools such as word processors and spreadsheets. Technology that allowed classes to be given by remote teachers via two-way audio and video, known as "distance learning," also first appeared in schools in the early 1980s and has become widespread. Distance learning programming, transmitted via cables, fiber optics, and satellites, expands access to instruction for students, particularly for those in remote regions of the nation and in underserved communities.

As we approach the 21st century, several new, more powerful technologies are just beginning to make their way into classrooms across the nation. For example, new personal computers support "multimedia" educational software that employs both sound and video to teach students facts and concepts. Advances in telecommunications technologies have spurred access to the Internet, allowing students and teachers to communicate with people from around the world via elec-

tronic mail, or "e-mail" as it is commonly known. New ways of obtaining and presenting information have given students powerful new ways of analyzing and understanding the world around them.

In fact, not only are new technologies more powerful, but they are easier to use and more accessible. Modified keyboards, joysticks, and head pointers allow students with physical disabilities to use computers.[6] Synthesized speech lets those with speech impairments "talk" by typing their words into a computer. And speech-to-text translators transfer the spoken word into written text, facilitating communication for those who cannot type, or choose not to.[7]

Through the use of advanced computing and telecommunications technology, learning can also be qualitatively different. The process of learning in the classroom can become significantly richer as students have access to new and different types of information, can manipulate it on the computer through graphic displays or controlled experiments in ways never before possible, and can communicate their results and conclusions in a variety of media to their teacher, students in the next classroom, or students around the world. For example, using technology, students can collect and graph real-time weather, environmental, and population data from their community, use that data to create color maps and graphs, and then compare these maps to others created by students in other communities.[8] Similarly, instead of reading about the human circulatory system and seeing textbook pictures depicting bloodflow, students can use technology to see blood moving through veins and arteries, watch the process of oxygen entering the bloodstream, and experiment to understand the effects of increased pulse or cholesterol-filled arteries on blood flow.

We now know — based on decades of use in schools, on findings of hundreds of research studies, and on the everyday experiences of educators, students, and their families — that, properly used, technology can enhance the achievement of all students, increase families' involvement in their children's schooling, improve teachers' skills and knowledge, and improve school administration and management. This chapter presents an overview of the benefits of technology use for education, as well as a discussion of the characteristics of successful technology-rich schools. It concludes with a call to continue investing in research and development in this area.

Enhanced Student Achievement

As an instructional tool, technology helps all students — including poor students and students with disabilities — master basic and advanced skills required for the world of work. As an assessment tool, technology yields meaningful information, on demand, about students' progress and accomplishments and provides a medium for its storage. As a motivational tool, technology positively impacts student attitudes toward learning, self-confidence, and self-esteem. Indeed, as the following sections demonstrate, these findings are not trivial and represent the many ways in which technology can be used as a powerful tool for enhancing student achievement.

When I hire someone at the drugstore, if they haven't got at least a little experience with computers, I probably don't even want to talk to them about a job.

— Local Business Owner, Plant City, Florida[14]

Basic Skills Instruction

Since its earliest classroom applications, technology has served as a very successful and efficient tutor for students learning basic reading and math skills. Teachers who employ CAI, for example, can drill students on specific topics for which they need extra help, such as with long division or

PEASE ELEMENTARY SCHOOL:

San Antonio, Texas

Problem solving with technology

At Pease Elementary School in San Antonio, Texas, students improved their own lives even as they learned how technology could be used to solve real problems. For the Global Laboratory project, students decided to test the air in their own, poor smelling classroom. Using primitive air pumps and testing tubes, students were surprised to find elevated carbon dioxide levels in the air. They replicated their experiments in other classrooms with similar results. Since they could not find the cause of the elevated carbon dioxide levels, they decided to seek help on a computer network. An environmental scientist responded to their questions. With his suggestions in hand, the students examined the school's construction and found that the likely cause was poor ventilation. Using word processors and graphics programs, the students developed a presentation of their findings for the school board which, after confirming the readings, repaired the ventilation system. The students then shared what they had learned on the network, which in turn prompted at least one other school to discover elevated carbon dioxide levels in classrooms.

spelling. Among the attractions of CAI are its ability to individualize instruction and to provide instant feedback. Many CAI applications not only mark student answers as right or wrong, but explain the correct answer. Since students are able to control the pace at which they proceed through their exercises, they are neither held back nor left behind by their peers. And, the instant feedback motivates them to continue. In a decade-long series of studies, students in classes that use CAI outperformed their peers on standardized tests of basic skills achievement by 30 percent on average.[9] (However, not all applications of CAI have been found to be so successful in all types of settings.)

Schools have also turned to videodiscs and multimedia software — which can store and play back extensive collections of multimedia images — to strengthen students' basic skills. Video and audio technologies bring material to life, enhancing students' ability to remember and understand what they see and hear.[10] Until recently, teachers have used video primarily as a visual aid to demonstrate events or concepts.[11] By incorporating pictures, sound, and animation in classroom activities, multimedia significantly enhances students' recall of basic facts, as well as their understanding of complex systems.[12]

Distance learning, delivered via live interactive transmissions, improves student achievement at least as much as traditional methods of instruction.[13] In addition — particularly for students in rural or remote schools — distance learning technology expands student access to the core curriculum by enabling students to take classes not typically offered at their own schools. In many cases, the instruction students receive is of high quality, because distance learning courses can attract exceptional teachers and content experts.

Finally, even as technology has helped students master the traditional basic skills of reading, writing, and arithmetic, it has created new ones — those related to the use of technology itself. By the 21st century, 60 percent of all jobs in the nation will require skills in computer and network use.[15] This means that any student who does not know the essentials of using computers — word processors, spreadsheets, databases, networks, and operating systems — will be at a distinct disadvantage.

Advanced Skills Instruction

In 1992, the Secretary's Commission on Achieving Necessary Skills focused the nation's attention on the fact that more than half of all high school students leave school without the problem-solving and reasoning skills necessary to find and advance in a good job. Fortunately, teachers have found that interactive educational technology is an invaluable ally in moving all students beyond the basic skills. Access to computer-generated simulations, videodiscs, the Internet, and software on CD-ROM offers students experiences available nowhere else — experiences that students will need for the 21st century. In fact, students with extensive access to technology learn how to organize complex information, recognize patterns, draw inferences, and communicate findings.[16] Not surprisingly, they exhibit superior organizational and problem-solving skills as compared to students in more traditional high school programs.[17]

It's the difference between looking at a picture of a heart in a textbook, and looking at a beating heart and being able to slow it down and analyze it to see exactly how it works, step by step.

— High School Science Teacher, Plant City, Florida[18]

One simulation software package, for example, allows students to assume the role of mayor of a large city. By governing the imaginary city, students learn about the interconnections and tradeoffs of modern society. Raising taxes results in more city services, but in less disposable income for residents (and a drop in public opinion polls for the mayor). Opening manufacturing plants increases employment, but harms the environment. Another program allows students to assume the role of a 19th-century Irish immigrant in Boston. Students experience the trip to the New World on a whaling vessel, practice writing by keeping journals of their life in their new homes, and strengthen math skills as they struggle to live within their budgets. Throughout, multimedia presentations help bring the period to life for the students, and word processors and spreadsheets give them the tools they need to complete their assignments.

Numerous studies have demonstrated that technology is particularly valuable in improving student writing. For example, the ease with which students can edit their written work using word processors makes them more willing to do so, which in turn improves the quality of their writing.[19] Studies have shown that students are more comfortable with and adept at critiquing and editing written work if it is exchanged over a computer network with students they know.[20] And student writing that is shared with other students over a network tends to be of higher quality than writing produced for in-class use only.[21]

Several mathematics software programs help students reach the high standards promoted by the National Council of Teachers of Mathematics and other professional groups. One of these products, for example, shows students how math can be used to solve problems encountered in real life. Each segment in the series presents mysteries or problems encountered by the main character that require mathematical solutions. In one, students must figure out if the main character has enough gas and time to get his boat home without refueling. The data necessary to solve the problems are embedded throughout the stories, requiring students first to determine which information is relevant to the solution and then to use their skills to solve the problem at hand. Another program teaches problem-solving and computer programming skills through a story about a planet with a disappearing rain forest. Students manipulate geometric shapes to repair damaged bridges, learn map-reading skills to navigate rivers and roads, develop logic skills as they program robots to help them, and use algebra to pack parcels they find along the way.[22]

Learning-disabled students can master complex problem-solving skills as well as nondisabled students with the support of educational technology.[23] In some cases, these students exhibit unique facility with

One thing I like about the computer is that it does give a lot of instruction — and you don't need to have hearing to take advantage of it.

— High School Student with a Hearing Disability,
Consumer Review Panel

technology and become highly valued tutors within the classroom. Word processors, teamed with carefully guided instruction, have enabled some students with learning disabilities to write well-reasoned and organized reports.[24] Studies of students with disabilities show that technology can expand access to educational resources and enhance students' ability to process and remember information.[25]

Assessment of Student Progress

Technology offers several advantages over traditional methods of student assessment.[26] For example, multimedia technology expands the possibilities for more comprehensive student assessments that require students' active participation and application of knowledge. The immense storage capacity enabled by technology such as CD-ROMs allows schools to develop electronic portfolios of students' work. A single CD can hold exact copies of students' drawings and written work, recordings of the child reading aloud, and video images of plays, recitals, or class presentations. By saving work samples on different subjects at different times during the year, teachers can display them in rapid succession to demonstrate and assess growth. A recent development, computer-adaptive testing, promises to administer tests more efficiently by automatically adjusting the level of difficulty of the questions until it correctly ascertains a student's level of proficiency.

BLACKSTOCK JUNIOR HIGH SCHOOL

Port Hueneme, California

Creating Smart Classrooms

Since moving to integrate technology in 1983, Blackstock Junior High School has seen results that are impressive: 8th-grade students are now scoring at or above the 90th state wide percentile in math, history/social studies, science, and writing. Measures of critical thinking skills rose from the 40th to the 80th percentile, average daily attendance has increased, and discipline problems have declined.

Blackstock's work to develop and support their learner-centered, technology-rich environment has created "smart classrooms." There are at present eight smart classrooms, including two for instruction in 7th-grade science, one for instruction in 8th-grade science, two for literature and history, one for ESL instruction, one for instruction in business education, and one called "Tech Lab 2000."

Tech Lab 2000 is best described as the futuristic equivalent of a wood or metal shop. Designed to make students familiar with the technology present in the modern workplace, the Tech Lab is outfitted with computer-assisted design (CAD) software, a computer numerically controlled (CNC) flexible manufacturing system, pneumatic equipment, and a satellite dish. All of the other smart classrooms have between 25-30 computers on a local area network (LAN). Each is also equipped with a sophisticated file server and a special switch to give the teacher maximum control over classroom dynamics. With the switch, students can all be working on the same project, or there can be a variety of things going on in the classroom at the same time.

Staff development efforts for teachers in the smart classrooms have centered on giving individual instructors large amounts of paid time off to familiarize themselves with technology and to organize a technology-based curriculum. Ongoing staff development for all teachers is supported by four paid days of technology training per year and a considerable amount of informal sharing.

Exposure to computers has changed the type of student I am and my methods for attacking problems. I now gain a far better understanding of the topics I pursue, and discover links and connections between them.

— High School Student, Midwest Regional Forum

Student Motivation

The use of technology in the classroom improves students' motivation and attitudes about themselves and about learning. Technology-rich schools report higher attendance and lower dropout rates than in the past.[27] Students are found to be challenged, engaged, and more independent when using technology.[28] By encouraging experimentation and exploration of new frontiers of knowledge on their own through the use of technology, students gain a greater sense of responsibility for their work — producing higher-quality assignments that reflect the increased depth and breadth of their knowledge and talent.[29] And technology energizes students, because they often know more about its operation than do their teachers.[30]

Increased Family Involvement

Technology offers new and exciting ways for families to increase their involvement in their children's education. For example, one project at several schools in one state provides 4th- through 6th-grade students with computers at home and modems to connect their home computers with their schools', thereby increasing the amount of time students spend on educational activities outside of school and increasing family involvement.[31] Students watch less television, improve problem-solving and critical thinking skills, improve their writing and math skills, and improve their computer skills. Parents communicate more with their children and their children's teachers, are more aware of their children's assignments, increase their own computer skills, use the computer for personal and business reasons (such as working toward a GED), and spend more time with their families. In fact, this program has become a vehicle for empowering students in other, less tangible ways. For example, since students are often more proficient with technology than their parents, they can teach their parents about the technology — an experience that improves students' self-confidence and skills.

Students in another school district created an electronic bulletin board service that provides students, family and community members, and staff with information on school activities, announcements, weather forecasts, academic materials, tutorials, and e-mail services.[32] The potential of these and other projects is why nine of every ten districts are, or are planning to, increase family involvement through home use of instructional software.[33] Other enterprising projects identify and recruit parent volunteers who have technology expertise to lend to schools. These volunteers can train teachers, install hardware and software, and offer other technology-related advice.

EAST BAKERSFIELD HIGH SCHOOL

Bakersfield, California

Education to Build Job-Related Experience

East Bakersfield High School emphasizes a technology-rich, school-to-work transition program in a school serving 2,400 students, with a majority considered at-risk. The result: fewer students are dropping out, and graduates are markedly more successful in finding work.

The curriculum is organized around five career tracks designed to allow students to develop technical and applied skills related to broad industry groups: science, technology, engineering and manufacturing; health careers; communications and graphic arts; human and government services; and business and entrepreneurship.

Technology-based instruction is integrated smoothly into coursework from beginning to end. As freshmen, students take a nine-week course in keyboarding and basic computer literacy. Writing assignments in the freshman English and history core courses are organized to ensure that all students moving into their sophomore year are proficient in the use of word processing programs. As seniors, students have to complete a technology-based project as a graduation requirement. Projects involve the use of computers, graphics software, or video equipment.

Administrators at East Bakersfield use a variety of measures to support technology-related staff development. There is a limited amount of funding available for paid, formal technology training — the school's staff development budget allocates an average of one paid day per teacher per year. To support informal development efforts, the school has established a teacher computer lab. And to keep the technology running smoothly, the school has a half-time technology coordinator, a full-time repair specialist, and a budget for hiring network specialists on an as-needed basis.

Improved Teachers' Skills

Technology helps teachers improve their classroom practice by expanding their opportunities for training and by fostering collegial work with other teachers and professionals.[34] For example, videodiscs and CD-ROM multimedia presentations are being used to show prospective teachers how contrasting styles of teaching affect student engagement and achievement.[35] Similarly, distance learning technologies are being used to deliver staff development courses across 90 school districts in California.[36] These courses are being led by experts, many of whom are teachers themselves. Teacher participants have the opportunity

I am changing the way I teach, because of the things I am able to do.

— High School Science Teacher, Northwest Regional Forum

to call in and interact with the experts by telephone, as well as to engage in discussions at each school site led by facilitators.

Particularly promising to teacher skill development are electronic networks that allow teachers to overcome the isolation they experience in their classrooms.[37] By bouncing ideas off peers and sharing experiences and resources with like-minded colleagues across the country, they are gaining enthusiasm, confidence, and competence. As one principal notes, "E-mail allows teachers to pose questions to each other and to me when they have the time. On the system, we can respond to each other at our convenience, and we avoid the 'let's talk later' syndrome that is part of working with children."[38] Other professional activities of teachers who use telecommunications include accessing relevant student information, accessing educational research, downloading lesson plans, and accessing libraries.[39]

Improved School Administration and Management

Similar to the experience of businesses in the private sector, technology used as an administrative and management tool enables principals and superintendents to save money, streamline operations, and monitor student progress. For example, the Guilford County school system in North Carolina uses a district wide interactive video network, resulting in cost savings by eliminating unnecessary travel, reducing busing, and using staff time more efficiently. A recent 30 minute curriculum planning meeting of three people on the network saved 72 miles in travel reimbursement and more than 3 staff hours of professional salaries. Students learning French IV over the network are no longer bused to class, which saves salary, fuel, and maintenance costs.[40] The Pinellas County, Florida, school system maintains a 13-year longitudinal database of costs and other inputs, school processes, and student outcomes to monitor ongoing school improvement efforts. School and district quality councils access the database regularly during strategic planning phases and annual evaluations of school and district programs. Additionally, the database allows the district to continue to track students who leave the district and enroll in other districts in the state.[41]

Characteristics of Successful Technology-Rich Schools

We know that successful technology-rich schools generate impressive results for students, including improved achievement; higher test scores; improved student attitude, enthusiasm, and engagement; richer classroom content; and improved student retention and job placement rates.[42] Of the hundreds of studies that show positive benefits from the use of technology, two are worth noting for their comprehensiveness. The first, a U.S. Department of Education-funded study of nine technology-rich schools, concluded that the use of technology resulted in educational gains for all students regardless of age, race, parental income, or other characteristics.[43] The second, a 10-year study supported by Apple Computer, Inc., concluded that students provided with technology-rich learning environments "continued to perform well on standardized tests but were also developing a variety of competencies not usually measured. Students explored and represented information dynamically and in many forms;

Technology, in and of itself, is not a magic wand. Technology is not going to fix the problems associated with schooling, but, at the same time, the problems that plague our educational system are not going to be remedied without the presence of technology.

— Researcher, Northeast Regional Forum

became socially aware and more confident; communicated effectively about complex processes; became independent learners and self-starters; knew their areas of expertise and shared that expertise spontaneously."[44] Moreover, research that demonstrates the effective use of technology is borne out in many successful schools across the nation. For example, the Carrollton City School District in Georgia reported a decline in the average failure rate for 9th-grade algebra from 38 percent to 3 percent after employing technology in its schools.[45] Leading edge technology districts are more likely to be located in affluent, suburban communities. Table 1 presents success measures of technology-rich schools with very different student populations.

Studies examining the success of technology-rich schools have revealed four key features that appear to represent best practices of the high technology school of the future.[47] The first feature emphasizes the role of *concentrated, conscious, and explicit planning among school leaders, families, and students to create "learner-centered" environments.* These learner-centered environments focus on how technology can support students' individual needs and capabilities, not on the capabilities of the technology itself.

As a corollary to this planning process, *the goals and challenging standards for student achievement are clearly articulated.* In successful technology-rich schools, these measures of student success are not simply limited to achievement test scores, but also include indicators of other important school processes, such as student motivation and engagement, job placement, attendance rates, dropout rates, and level of family involvement.

A third feature emphasizes *the restructuring of the school to support the learner-centered environment and achievement of standards.* Successful technology-rich schools physically reorganize and redesign their classrooms and school buildings, rethink their use of time,

TABLE 1

SUCCESS MEASURES IN TECHNOLOGY-RICH SCHOOLS[46]

School	Student Population	Measures
Christopher Columbus Middle School Union City, NJ	91 percent minority, 79 percent free-lunch eligible	Rising scores on state tests; improved student attendance
Blackstock Jr. High School Port Hueneme, CA	65 percent minority, 76 percent Title I	Improved test scores; increased student comprehension, motivation, attitude; strong student, parent, and teacher support
East Bakersfield High School Bakersfield, CA	60 percent minority, very low English proficiency	Improved student retention; improved placement in jobs
Northbrook Middle School Houston, TX	Largely minority, low socioeconomic status	Sharply improved test scores

NORTHBROOK MIDDLE SCHOOL

Houston, Texas

Preparing life-long learners for the world of work

Northbrook Middle School students use technology as a tool to increase their learning and productivity in all subjects. Since it reopened in 1991 with a commitment to a technology-rich, learner-centered environment, Northbrook has seen test scores, attendance records, student attitudes and self esteem, and discipline all improve. Setting aside 25 percent of its $6 million startup costs for networking, hardware, and software costs, Northbrook Middle School is a new creation in an old building. It serves a 6th- through 8th-grade population of under 800 students drawn largely from families of Hispanic migrant workers.

The school itself is organized into four learner-centered clusters. Teachers and students in each cluster work together to support one another in gathering information and solving problems. Technology is employed to help students develop critical thinking and problem solving skills, as well as to tailor instruction to individual student needs.

With over 400 computers in place in the school's six technology labs and 48 classrooms, Northbrook has a student-to-computer ratio of just under 2:1. Each of the school's classrooms is outfitted with five or six computers. All of the computers have built-in CD-ROM capabilities in order to expand the range of software products available for student use. Access to network resources supports student information searches. Computers in the classrooms, in the computer labs, and in the library are networked together in a school wide LAN with Internet connectivity.

To support the technology program, Northbrook has relied primarily on on-site staff development. Each of the school's 48 teachers received two weeks of technology-related staff development in the summer prior to the school reopening. On an ongoing basis, teachers participate in three to four days of paid training each year on average. Additional personnel supporting the technology program include a full-time technology assistant and a part-time district technology coordinator. These two individuals conduct training and keep the technology running smoothly.

reevaluate the manner in which they deliver their curriculum, and build better partnerships among teachers, administrators, parents, and students.

For example, within the framework of this learner-centered environment, a successful technology-rich school may lengthen its class periods to accommodate an interdisciplinary program, which is enhanced through the use of technology. Teachers may lecture less and require more interaction and discussion from students. Properly supported with technology, many students with disabilities remain in regular classrooms with their peers, or reduce their need for school-related services.[48] In these and similar ways schools are restructured to become learner centered.

The fourth and final feature common to successful technology-rich schools is *near universal access to computer technology* — at least one computer for every five students. To accomplish this level of access, successful schools spend about three times as much on technology-related costs as do average schools. In some cases, these schools spend more than five times the average. Additionally, many currently successful technology-rich schools secure an initial investment of external funding to defray the startup costs of technology and training.

Conclusion

While research studies and the experiences of technology-rich schools demonstrate that current technologies are powerful tools for improving many aspects of the nation's schools, we must remain poised to take advantage of new and potentially exciting opportunities as they emerge. After all, three years ago technologies such as CD-ROMs and the Internet were virtually unheard of in schools. Today, we can see that they offer the nation's children a brighter future.

To that end, we also must continue our research and development efforts to understand those and other rapidly emerging educational technologies. Past investments in research and development in technology have paid huge dividends to education. The development of the microcomputer grew in part out of NASA's space exploration program in the 1960s and 1970s. The Department of Defense's Advanced Research Projects Agency (ARPA) began experimenting with computer networks in the 1950s, leading to the development of the Internet. The National Science Foundation enabled the Internet to form by expanding its reach and supporting research and development on networks. The Kurzweil machine, which converts written words into speech, was developed in part with the support of the U.S. Department of Education. To remain competitive in the 21st century, we cannot afford to miss any benefits technology might afford us.

"As we prepare to enter the new millennium, we are learning a new language. It will be the lingua franca of the new era. It is made of ones and zeros and bits and bytes. But as we master it, as we bring the revolution into our homes and schools, we will be able to ideas and with an ease never before thought possible. Let us master and develop this new language together."

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—Vice President Gore

REACHING THE TECHNOLOGY GOALS

Progress Report

In his State of the Union address in January 1996, President Clinton called for a national partnership to ensure that every classroom is "connected to the information superhighway with computers and good software and well-trained teachers." On February 8, 1996, the president signed the Telecommunications Act of 1996, which will help ensure that every child in every classroom in America will be connected to the information superhighway — opening up worlds of knowledge and opportunities. And on February 15, 1996, President Clinton and Vice President Gore announced the Technology Literacy Challenge, designed to energize the nation to make young Americans technologically literate by the turn of the century. The challenge is for communities, private companies, state leaders, and individuals — including students and their families — to work together to reach the technology goals.

Many local communities and states are already making substantial progress toward reaching these goals with the assistance of both the private sector and the federal government. Progress to date is discussed below in relation to each of the four goals.

Goal 1: All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway.

Professional development is key to effective technology integration and to increased student learning. Teachers need access to technology and ongoing support while

Professional developme[illegible]ssues are important issues and these are long-range, ongoing issues. Professional development must acknowledge what's going on in the classroom and what teachers need.

— High School teacher, Far West Regional Forum

they learn. They need adequate time to acquire new skills to integrate technology into their schools' existing programs and activities. And teachers learn best with, and from, their colleagues. If there is a single overarching lesson that can be culled from research about teacher professional development and technology, it is that it takes more time and effort than many anticipate. For example, the Office of Technology Assessment estimate that it can take up to five years to effectively infuse technology into schools.[49] All teachers need to be trained and supported over that period.

In recent years, rapid progress has been made toward the goal of training every teacher:

- More than 50 percent of teachers owned a computer at home in 1993.[50]
- New, challenging standards adopted in September 1995 by the National Council for the Accreditation of Teacher Education require that all students in teacher education programs take at least one course on the integration of technology into teaching and learning.
- The state of North Carolina now requires all teachers to complete at least three courses in the use of technology in order to be recertified, and requires that 20 to 30 percent of technology funds be spent on training for teachers.
- Through on-line networks, teachers are helping each other to learn new technological skills. For example, the Texas Education Network, an electronic resource used by more than a quarter of Texas teachers, enables teachers to share ideas and access a library of lesson plans. Its peak time of use is on Sunday evenings, as teachers prepare for the week ahead. By 1995, 38 states had established similar networks for teachers and other educators.[51]

Despite these promising developments, *the nation has a long way to go:*

- Only 14 percent of public school teachers had more than 8 hours of training (in-service or professional development programs) in the area of educational technology in the 1993-94 school year.[52]
- As many as 50 percent of teachers have little or no experience at all with technology in the classroom.[53]
- Much current professional development is in the form of one-shot seminars that are insufficient to bring the teaching profession up to speed with emerging technologies.[54]
- Currently, only 18 states require training in technology for all teachers seeking certification, and only 5 require technology training for teacher in-service.[55]

Goal 2: All teachers and students will have access to modern multimedia computers in their classrooms.

To make technology a viable instructional tool requires schools to have enough computers to provide full, easy access for all students, including students with disabilities. Although the national student-to-computer ratio is currently 11:1, the ratio of students to powerful multimedia computers is only 35:1.[56] In contrast, many studies suggest that full, easy access requires a ratio of about five students to each multimedia computer.[57]

To ensure that the wealth of opportunities afforded by state-of-the-art technologies is accessible to students with disabilities, researchers (in large part sponsored by the U.S. Department of Education) are making great strides in designing new technologies to meet the indi-

vidual learning needs of students with disabilities. Department-funded researchers worked closely with the developers of Windows 95, for example, to ensure that it included accessibility features for people with disabilities.

Here are some of the ways states, communities, and the private sector have approached the problem of access:

- Voters in Maine approved a $15 million bond issue for technology in November 1995, and the Bethel School District in Oregon recently approved $3 million for technology in schools.
- Kentucky has a master bid list that any school district can use to order computers, software, and other equipment, for bulk purchasing.
- Several national and local organizations are matching companies with used equipment to school districts that can use it. Refurbishing, upgrades, and technical assistance to the schools are important elements of this strategy.
- Several companies are currently working to develop lower-cost computers or new ways of networking computers within schools and districts that could dramatically increase the buying power of schools.

Problems remain, however:

- The installed base of computers is largely composed of machines with fewer capabilities and functions than today's multimedia machines.[58] Many of the older and less powerful computers in schools are unable to run the latest software or access the Internet.
- Over half of schools still report that the majority of their computers are in computer labs.[59] Only when computers are installed throughout a school building will students have regular access to them during the school day and in class.
- While businesses, researchers, and non-profits are developing innovative strategies and tools to make technology accessible to students with disabilities at home, in school, and in the community, technology remains inaccessible for many students with disabilities. For example, icon-based systems on the World Wide Web are inaccessible to blind individuals.

Goal 3: Every classroom will be connected to the information superhighway.

Connections to local area networks (LANs) and the Internet turn computers into versatile and powerful learning tools. Access to these networks introduces students and teachers to people, places, and ideas from around the world to which they might otherwise not be exposed. Surveys conducted by the National Center for Education Statistics in 1994 and 1995 indicate the progress made to achieve these connections:

- In 1994, 35 percent of schools had access to the Internet; a year later, that number had grown to 50 percent.

From my perspective, technology is to today's classroom what paper and pencil were to yesterday's classroom — an essential ingredient in our age of information. In fact, technology is the paper, pencils, encyclopedia, dictionary, thesaurus, textbook, and library all rolled into one.

— District Superintendent, Northwest Regional Forum

- In 1994, 3 percent of all instructional rooms (classrooms, labs, and media centers) in public schools were connected to the Internet; in 1995, this had grown to 9 percent.
- Fifty-five percent of schools indicated that funding was a major barrier to the acquisition or use of telecommunications, down from 69 percent in 1994.

- Of the 50 percent of schools that do not have Internet access, 74 percent have plans to secure access in the future.
- In the 18 months from January 1995 to June 1996, the number of schools with World Wide Web sites on the Internet went from 134 to 2,850 — an exponential rate of growth (Figure 1).

While progress toward the goal of connecting every classroom is rapid, *much remains to be done*:

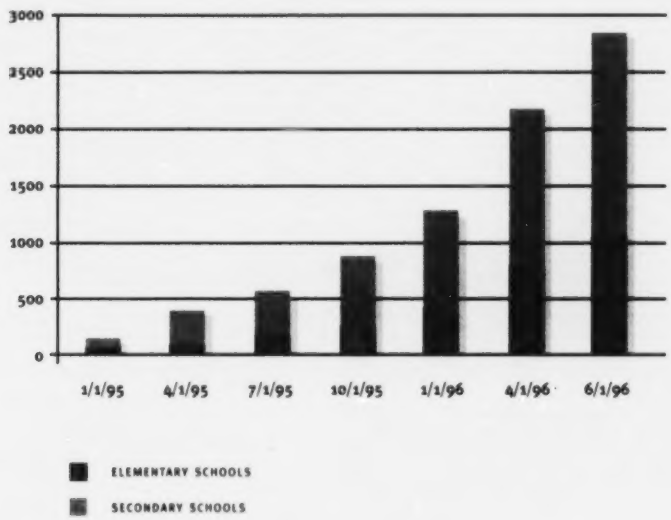
- In 1995, only half as many schools in poor areas (31 percent) had Internet connections compared with schools in the wealthiest communities (62 percent).
- Small schools, high-poverty schools, and elementary schools are the least likely to have Internet connections, and the least likely to have plans for such connections.
- Funding remains the number one barrier to widespread use of telecommunications. In addition, the two next largest barriers are directly related to funding. Forty-seven percent of schools cite too few access points within school buildings, and 40 percent cite the poor quality or lack of equipment.

Goal 4: Effective software and on-line learning resources will be an integral part of every school's curriculum.

Computer software, video, distance learning courses, and on-line resources are expanding rapidly. For example, over 20,000 educational software titles have been developed, more than a million students take courses through distance learning networks every year, and every day hundreds of new home pages are added to the Internet's World Wide Web. These resources

FIGURE 1

THE EXPONENTIAL GROWTH OF WORLD WIDE WEB SITES IN U.S. SCHOOLS



Source: Web66 International Registry of School Web Sites
Stephen E. Collins, University of Minnesota <http://web66.coled.umn.edu/>

We definitely need teachers to help identify good software — to put some models out there that producers can emulate. Teachers need to be involved in separating the wheat from the chaff.

— Software Publisher, Far West Regional Forum

hold promise to improve learning, increase the amount of time students spend learning, and engage students in problem solving, research, and data analysis. There has been notable progress to date in making such opportunities available:

- The academic standards completed in 1990 by the National Council of Teachers of Mathematics have resulted in broad consensus among educators about what students should know and be able to do in mathematics at different grade levels. Software developers, in turn, are using these standards to develop new products that can be used in schools. Some school districts, as well, now link software to these standards so that teachers know what programs will help their students learn the appropriate concepts.
- In the Springfield, Oregon schools, students with learning disabilities participate in regular earth science and chemistry courses through the use of videodisc software that teaches higher-order problem-solving skills and concepts in science. The software enables high school students with learning disabilities to score as well as their peers on an advanced-placement high school chemistry test.
- The Internet provides many promising new learning opportunities. For example, San Francisco's Exploratorium offers on-line interactive exhibits for students. In addition, by using free video conferencing software developed at Cornell University, schools can see one another, demonstrate projects, and work collaboratively on-line.
- Teachers and students are creating World Wide Web pages for their schools that include portfolios of best works, virtual tours, and special projects. In addition, several national efforts such as Midlink Magazine exist to publish student work on-line.
- In the future, digital libraries will provide access to huge databases of information. Collections such as those in the Library of Congress and the American Museum of Natural History in New York are being prepared for student use.

Projects that lend elementary students computers and modems to connect to school have increased the amount of time students spend learning, as well as increased family involvement.[60]

Despite the growth of resources, significant challenges remain:

- Software that can be directly linked to the local curriculum and high standards, supplementing the traditional textbook, is still the exception. The best new software is mostly for reading and math in the early grades.
- Educational software use by students at home is heavily skewed to higher-income families because wealthy families are many times more likely to own computers than poor families.[61]
- Software companies avoid developing educational software for school use, because they can lose money even if they succeed in cornering the school market. They argue that the school market is too small from which to profit.[62]

- Many states, schools, and families do not have a way to judge the effectiveness of software programs in increasing student achievement before purchasing them.
- The quantity of information on the Internet is staggering and finding needed information quickly can be difficult. New, more effective "filters" to help teachers and students find accurate, up-to-date, high-quality information are necessary.

Cost of Meeting the Four Goals

Many communities across the country are responding to the demands of the digital age, and are already making substantial investments in technology for education. However, meeting the four goals of the technology literacy challenge by early next century will require an accelerated investment.

There is no one "formula" for integrating technology into the classroom and school curriculum. The nature and level of technology use will depend on the educational priorities of individual communities. Furthermore, the rapid pace of technological change and advancement would call into question any attempt to prescribe a formula. CD-ROMs and the Internet were virtually unheard of in schools three years ago. Change will continue to occur at a rapid pace, creating new opportunities and even potentially lowering costs. After all, the relative cost of computing power has halved about every three years since the 1950s, and on the not-too-distant horizon are lower cost computer terminals and wireless networking technologies.[63]

Schools, like private firms, need to develop an investment mentality for technology based on the understanding that new technologies involve not simply a one-time, up-front cost for equipment, but also ongoing, recurrent expenses. These recurrent expenses involve costs to upgrade hardware and software, maintain special furniture and cabling, replace materials and supplies, and continually upgrade the skills and competence of teachers and administrators.

Nationally, about $3.3 billion was spent on technology in the 1994-95 school year with projected annual growth ranging from 11 to over 15 percent per year. While exact data are unavailable, approximately one-fourth, or $800 million, comes from federal sources, including Title I (formerly Chapter 1), Title VI (formerly Chapter 2), the Eisenhower Professional Development Program, the Job Training Partnership Act (JTPA), and other programs. Other sources are local funds (40 percent), state grants (20 percent), and business and other contributions (15 percent).[64]

Types of Costs

The kinds of costs for integrating technology into schools fall into several categories, some of them not immediately obvious:

- **Hardware,** such as computers, printers, scanners, and other equipment, sufficient to give all students ready access to these tools.
- **Software** and other educational content, such as remote databases of information, video programming, courses taught using distance learning technologies, and access to the Internet.
- **Internal connections** between classrooms and within the school building. In older buildings, these connections can be expensive because they involve asbestos removal or the use of wireless networks.
- **Professional development** so that teachers and other school staff can learn both how to use the technology and how to integrate it into their school's curriculum.
- **Ongoing technical support** for teachers, many of whom are reluctant to use technology in their lessons unless they have access to immediate help, when necessary, during the school day.
- **External connections** that require initial connection fees and ongoing telecommunications charges for a school's telephone lines, satellite connections, and cable connections, and fees for school Internet access.
- **Infrastructure improvements**, such as increased electrical capacity to handle computer equipment, better ventilation and cooling systems, and additional telephone lines.
- **System maintenance and upgrading** of hardware to preserve and ensure effective use of schools' investments in technology.

Cost Estimates

The estimates of the cost of meeting the President's four goals for technology in education vary considerably. This can be attributed to different visions of how schools should be equipped, the extent to which teacher training is required, and the different levels of preparedness of schools today. Some school buildings will require major and potentially costly improvements in electrical systems before computers can be used in all classrooms. Similarly, schools in rural areas face the prospect of higher costs for connections to the information superhighway.

A number of organizations have developed cost estimates based on varying models of technology deployment. Among these organizations is McKinsey and Company, which in 1995 completed the most comprehensive estimate to date of the costs of implementing technology in all of the nation's schools. Based on a model of one multimedia computer for every five students, connections to the information superhighway in every classroom, every teacher trained in the use of information technologies, and adequate software to help students meet high academic standards, McKinsey estimates the cost to be $109 billion over 10 years, or an average of approximately $11 billion per year.[65]

An analysis by the RAND Corporation of technology-rich schools estimates the combined initial and ongoing costs of technology at between $8 billion and $20 billion per year over five years, depending on the number of computers per student, the intensity of professional development, and other factors.[66] The Telecommunications Industries Analysis Project (TIAP) developed another estimate, with seven students per computer, of $10 billion to $12 billion per year over five years.[67]

These cost estimates range from three to six times what is currently being spent for purchasing and supporting the use of educational technology in schools across the nation and would represent a significant increase in current discretionary expenditures for instructional materials, such as for books and other curriculum supplies. However, when viewed in the context of the total public elementary and secondary school enterprise, which serves more than 43 million

There is no one "formula" for integrating technology into the classroom and school curriculum. The nature and level of technology use will depend on the educational priorities of individual communities.

TABLE 2

CURRENT SCHOOL TECHNOLOGY INVESTMENTS VERSUS THOSE OF TECHNOLOGY-RICH SCHOOLS[66]

Cost Item	Current School Conditions and Investments (1994-1995)	Conditions and Investments in Technology-Rich Schools
Computer density	35 students per multimedia computer[70]	Fewer than 5 students per multimedia computer
Building infrastructure	$220,000 per year in average capital improvements per school (includes new construction and improvements)[71]	Up to $250,000 in one-time technology-related improvements per school
Professional development and ongoing support	9 percent of technology budget[72]	38 percent of technology budget
Annualized technology expenditures per student	$70 per year	$180-450 per year for initial five years of deployment
Total annualized expenditures for educational technology	$3.3 billion[73]	$8.0 to 19.9 billion

elementary and secondary students, the costs seem more modest, ranging from 3 to 7 percent of total expenditures for the 1994-95 school year.

Funding Challenges

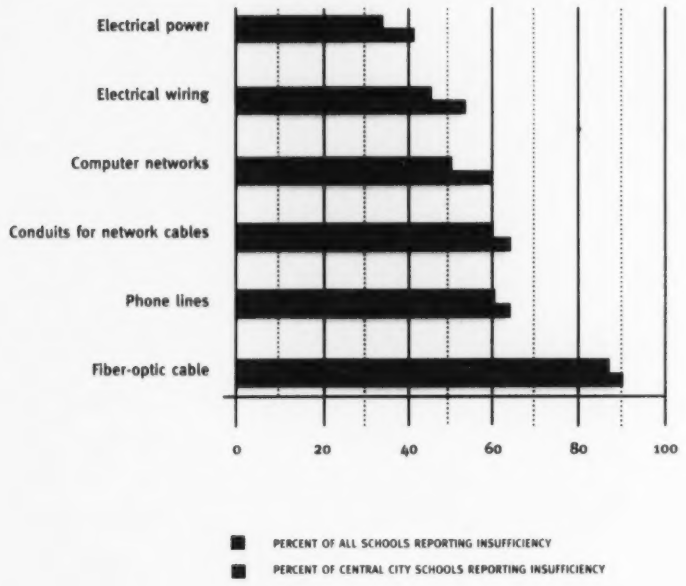
An examination of technology-rich schools provides several insights into the overall funding challenges faced by the nation (see Table 2). First, to integrate technology fully into students' learning experiences, schools need a much higher density of multimedia computers and related equipment than is currently present in schools. Even with rapidly falling hardware costs, this will mean substantial new investments for many schools. Many of the computers in schools today are more than five years old; some are ten years old. These computers will need to be replaced. Other, newer computers can be upgraded for a few hundred dollars each.

Second, implementing technology means much greater investments for teacher training and ongoing support of teachers in the classroom. Many fully equipped schools have a full- or part-time technology coordinator whose job it is to maintain equipment, provide on-the-spot assistance to teachers in the classroom, and assist teachers with identifying technology-based resources (such as software, video programming, on-line databases, and use of the Internet). Today, schools spend an average of 9 percent of their technology budgets on training and support, while the experience of technology-rich schools suggests that more than 30 percent of much larger technology budgets should be invested in these areas.[68]

Third, schools, particularly older ones, face a need for significant building improvements. Figure 1 displays the proportion of schools responding to a 1995 General Accounting Office survey of the adequacy of the infrastructure in place to support technology as compared to the adequacy of infrastructure in central city schools. It shows that half of all schools do not have adequate electrical wiring (such as outlets) to

FIGURE 2

REPORTED INFRASTRUCTURE INSUFFICIENCY (1995)[74]



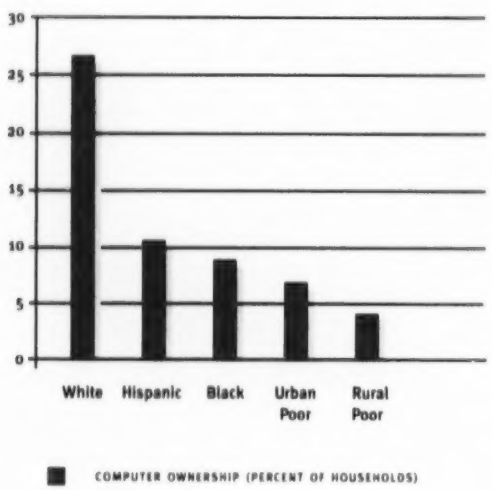
handle their technology needs. More than half do not have sufficient telephone lines, and 60 percent consider the number of conduits for network cable unsatisfactory. Schools that have all of these infrastructure elements are clearly the exception to the rule. Strikingly, schools in large central cities are even less equipped to meet the demands of technology than other schools; more than 40 percent do not even have enough electrical power to use computers on a regular basis.

These estimates and analyses of the funding challenges communities face indicate that the costs of implementation are far greater than what schools currently spend, despite the rapid growth of expenditures in recent years. While the federal government and private sector can make contributions, local communities and state governments will be challenged to meet these costs.

Of course, some schools will reach these goals much sooner than others. Classrooms in older buildings, for example, may require expensive renovations to improve electrical systems before computers and networks can be installed, discouraging the community from making a commitment. Meeting the enormous cost of implementing technology in schools, then, raises some important questions about how to ensure that all American students get access to these vital tools of education.

FIGURE 3

COMPUTER OWNERSHIP BY HOUSEHOLD AND ETHNICITY (1995)



No Community Left Behind

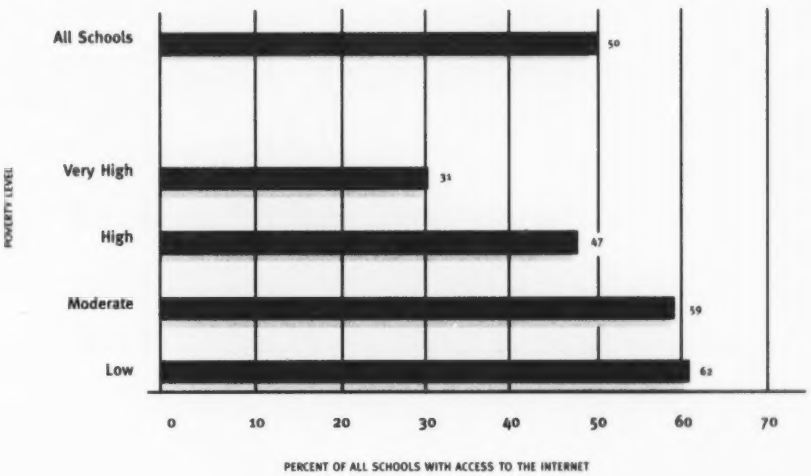
One of the most formidable challenges to meeting the nation's technology goals is ensuring that no community is left behind. All classrooms in all types of communities need updated technology and trained teachers if the nation is going to prosper.

Studies conducted by the National Center for Education Statistics reveal that, as compared to more affluent schools, schools with high concentrations of students who are poor are less likely to have access to computers and less likely to have access to the Internet.[75] Furthermore, studies suggest that many schools in poor areas tend to use computers only in computer labs and merely to develop basic skills such as typing and word processing, while other schools have begun to integrate and use technology in more powerful ways, such as to access remote libraries and digital databases.[76]

For many children, the lack of access to computers at school is made up by the fact that many more families now own computers. But household possession and use of computers and network services is already reflective of a digital divide; it is heavily skewed toward middle- and upper-middle-class homes. Low-income citizens and black and Hispanic Americans, urban and rural, are much less likely to own computers than others. As Figure 3 demonstrates, white Americans are two to three times as likely to own computers as black or Hispanic citizens, and six to seven times more likely to own them than the rural poor, whatever their ethnic background. With attention to this issue, and by making high-quality resources available everywhere, technology can help all children reach their maximum potential.

FIGURE 4

ACCESS TO THE INTERNET IS NOT EQUAL



POVERTY RATES	PERCENT OF STUDENTS ELIGIBLE FOR FREE OR REDUCED PRICE LUNCHES
LOW	less than 11 percent
MODERATE	11 to 30 percent
HIGH	31 to 70 percent
VERY HIGH	71 percent or more

Source: U.S. Department of Education, National Center for Education Statistics, 1996

It makes each of our schools larger. It makes each of our schools more effective. It lets us offer students experiences and information they wouldn't otherwise have.

— Middle School Teacher, Midwest Regional Forum

The 21st century is America's for the taking — if we are bold enough and strong enough and confident enough to go forward together. We will make the best of this new together. We will educate our children with it, improve our businesses with it, make our government more democratic with it, and build a brighter, freer, more prosperous with it. That is the American way.

President Clinton

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ROLES SUPPORTING LOCAL ACTION PLANS

The nation is working toward making all students technologically literate by early next century. There has been considerable initiative and funding devoted to this end in some states and communities. At the same time, it is evident that the nation has a long way to go before reaching our goals for technology in schools. Although the federal government has an important leadership role, states and local communities have the most at stake and will have the largest role. The purpose of this report is not to prescribe a single plan of action; instead, it offers a strategic framework to support efforts by states and local communities to develop their own plans for promoting the achievement of high standards by all students through the application of technology.

Role of the Federal Government

The federal role, though limited, is to provide the leadership momentum for reaching the educational technology goals through targeted funding and support for activities that will catalyze national action. Indeed, federal support has been critical over the years as a catalyst for technology development and for providing incentives for schools to implement educational technology programs. (See Appendix B for examples of federal support for technology in education.)

Technology Literacy Challenge Fund

States, communities, and the private sector face a challenge of massive proportions, in terms of effective innovation and school improvement, as well as in terms of substantial investments and reprioritizing of school budgets. The purpose of the Technology Literacy Challenge Fund is to serve as a catalyst for states, local communities, companies, universities, and individuals to work together on a common set of goals. The president has asked Congress to appropriate $2 billion over five years for the fund. For the fund to succeed, each federal dollar will have to be matched by dollars and in-kind contributions from state, local, and private-sector sources. The president has included the first installment of this fund — $250 million — in his 1997 budget.

The fund would provide states with maximum flexibility. To receive funds, states would have to meet only these basic objectives:

- Each state would develop a strategy for enabling every school in the state to meet the four technology goals. These state strategies would address the needs of all schools, from the suburbs to the inner cities to rural areas. Strategies would include benchmarks and timetables for accomplishing the four goals, but these measures would be set by each state, not by the federal government.
- State strategies would include significant private-sector participation and commitments, matching at least the amount of federal support. Commitments could be met by volunteer services, cost reductions, and discounts for connections under the expanded Universal Service Fund provisions of the Telecommunications Act of 1996, among other ways.
- To ensure accountability, each state not only would have to set benchmarks, but also would be required to report publicly at the end of every school year the progress made in achieving its benchmarks, as well as how it would achieve the ultimate objectives of its strategies in the most cost-effective manner.

By design, states would have tremendous flexibility. Because the states are at different points in financing and using educational technology in the classroom, this flexibility is necessary so each state can address its own particular needs according to a technology plan that it develops itself.

Affordable Connections

The president and vice president have made connecting every classroom in America to the information superhighway by the year 2000 a national goal. To deliver on that goal, on February 8, 1996, the president signed into law the Telecommunications Act of 1996, which ensures that schools and libraries have affordable access to advanced telecommunications service. The law requires telecommunications carriers to provide service to schools and libraries at reduced rates.

The federal government will play an important role in effectively implementing the law so that access is real and affordable and classrooms are connected in all of our communities, including rural and urban areas. Making the new law work for the nation's schools and libraries will involve many players: the Federal Communications Commission, state public utilities commissions, service providers, rate payers, and the education community. The secretary of education, the chairman of the Federal Communications Commission, and other federal officials will provide leadership, convene educators and regulators to identify solutions, and build a broad base of support for affordable access.

Improved Professional Development

The federal government has an important role in expanding and improving professional development for teachers, in order to reach the goal that all teachers have the training they need to use technology. First, it provides funds for professional development through the Eisenhower Professional Development Program, the Teacher Enhancement Program, and other programs. The Departments of Education and Energy, NASA, the National Science Foundation, and other agencies all support teacher professional development. These investments must be expanded and greater emphasis on the use of technology added. Second, the Department of Education can provide leadership by highlighting the importance of sustained professional development and by disseminating information about what works in teacher training. The Department will convene states, school districts, colleges of teacher education, professional organizations, teacher unions, and others with a stake in improving pre-service and in-ser-

One of the key lessons from our experience so far is that a collaborative model is essential for sustained school improvement and student achievement. Business, government, and, of course, education all have something unique and valuable to offer.

— Representative from a Telecommunications Firm

vice training in order to galvanize commitments to provide effective training and support to all the nation's teachers. The Department of Education can also collaborate with national teacher accreditation bodies to support the development of model standards that integrate technology into requirements for graduation and state certification.

Improved Educational Software

The development of high-quality educational software depends on greater collaboration between educators and the private sector. The Department of Education, in coordination with other federal agencies, can support this collaboration in a number of ways. For example, it can sponsor workshops that bring together state and local educators, researchers, publishers, software developers, on-line services, cable and wireless operators, and other commercial providers of educational technology materials. Workshops would focus on issues such as how the market can meet the needs of today's classrooms better; how software can support higher student achievement; what students should know and be able to do (state standards); how states and school districts can develop better tools for evaluating the quality of the software on the market; and what are the lessons of current practice and research for future software development. The Department, through its educational technology programs for individuals with disabilities, has been instrumental in making more software accessible to students with disabilities.

THE TECHNOLOGY LITERACY CHALLENGE FUND

Catalyzing State, Community, and Private Sector Efforts

The technology literacy challenge fund would support a wide variety of innovative efforts.

- Districts and schools may provide funding for on-demand technical assistance to help technology-using teachers during the school day.
- Districts may link schools electronically to gather and maintain administrative data.
- States and districts may enter partnerships with the private sector and universities to develop software geared to challenging state academic standards.
- States and districts may build high-speed networks carrying voice, video, text, and graphics that connect schools.
- Districts may provide incentive grants, awards, and salary increases to individual teachers who make a commitment to upgrade their knowledge of computers and technology.
- States may target funds to communities that are farthest behind in effective use of educational technology.
- States and districts may collaborate to find cost effective ways of purchasing and using hardware and software.

PRESIDENTIAL CHALLENGES TO SPUR COLLABORATIVE EFFORTS

To meet the nation's technology goals, President Clinton and Vice President Gore have challenged the private sector, retirees, and educators to work together in new ways to improve student learning through the use of technology. States, communities, businesses, and individuals around the nation have risen to meet this challenge. For example:

- **NetDay 96: An electronic barnraising**
  The president and vice president brought together telecommunications and computer industry leaders in September 1995 to kick-start a historic effort to connect California classrooms to the Internet. On March 9, 1996, more than 20,000 parents and volunteers and more than 200 businesses in California installed and tested about 6 million feet of wire to connect classrooms in 2,600 schools to the Internet. Since California's successful "electronic barnraising," over 30 states have embarked on their own efforts.

- **Tech Corps: Volunteering expertise**
  The Tech Corps, launched on October 10, 1995 as a private-sector response to the president's and vice president's national mission to make all children technologically literate by the dawn of the 21st century, is a national non-profit organization of private sector volunteers with technological expertise dedicated to helping improve K-12 education at the local level. Its mission is to recruit, place, and support volunteers from the private sector who advise and assist schools in using new technologies in the classroom to improve student learning. Since October, leaders from industry and education have been working together to establish Tech Corps organizations in all 50 states.

- **American Technology Honor Society: Recognizing student expertise**
  The American Technology Honor Society was formed on October 10, 1995. This organization, sponsored by the National Association of Secondary School Principals and the Technology Student Association, is the school-based organization through which students with technology expertise can help expand their school's use of technology. It will recognize and reward students who use their technological expertise to serve their schools.

- **21st Century Teachers**
  On May 29, 1996, a coalition of 11 major education organizations, including both major teachers' unions, announced the creation of a voluntary corps to help more teachers learn how to use new technology to improve teaching and learning. One hundred thousand teachers will each train five of their colleagues during the 1996-97 school year. Teachers can sign up on a special World Wide Web site to participate in this effort.

Continued Investment in Educational Technology

In addition to the Technology Literacy Challenge Fund, it is critical that the federal government continue to target investments to address particular needs in educational technology. For example, to demonstrate new models of how information infrastructure can benefit the nation's schools, the Department of Commerce's Technology and Information Infrastructure Applications Program (TIIAP) provides grants to develop telecommunications networks for educational and other services. The Department of Education's Challenge Grants for Technology in Education award grants to school districts in partnership with businesses, museums, universities, and other institutions to develop a new generation of learning tools and curricula. To address the special needs of remote schools, the Department of Agriculture supports telecommunications links to provide students with access to advanced courses and other distance learning opportunities, and the Department of Education's Star Schools program provides seed funding for distance learning providers.

To focus on the particular challenges of teaching math and science, the National Science Foundation funds programs that demonstrate how electronic networks can support education reforms and improve math and science teaching. Likewise, NASA develops model curricula using state-of-the-art technologies; and an innovative program called Global Learning and Observations to Benefit the Environment (GLOBE) links students, educators, and scientists around the world in a long-term effort to make observations of the environment and share the data via the Internet. The 140 schools run by the Department of Defense on military bases around the world are becoming a powerful model and effective testing site for the use of advanced technologies for learning.

Effective Use of Technology by Major Education Programs

Among the federal government's largest education and training programs are the Goals 2000: Educate America Act, the School-to-Work Opportunities Act, Head Start, the Elementary and Secondary Education Act (ESEA), the Perkins Vocational and Applied Technology Education Act, the Job Training Partnership Act, and the Individuals with Disabilities Education Act. Programs under these acts allow funds to be used for educational technology, including training teachers to incorporate technology into their classrooms, and purchasing software and hardware. For example, according to one estimate, in 1995 schools invested about $450 million under Title I (formerly Chapter 1) of ESEA in educational technology in order to help students in low-income schools improve basic and advanced skills in the core academic subjects.[37]

The federal government will continue to promote the use of educational technology as an important element of improving the achievement of students served by these programs and, through high-quality technical assistance, it will help to ensure that technology is used as effectively as possible to improve teaching and learning. It will also continue to increase flexibility in the use of funds under these programs, as it did in the recent reauthorization of Title I, which has made it easier to make technology purchased with Title I funds available to all students in a school.

Clearinghouse for Good Ideas

Helping states, school districts, schools, teachers, parents, professional organizations, and the private sector know and share what works is a vital function of the federal government. The federal government will continue to disseminate accurate and up-to-date information about what works in educational technology through the Department of Education's technical assistance provider network, which includes an on-line library; the Educational Resources Information Center (ERIC) Clearinghouses; the Regional Technology in Education Consortia (R*TECS); the Technology Related Assistance Program for Individuals with Disabilities; The Eisenhower National Clearinghouse on Math and Science Education; and the Department of Energy's national laboratories and specialized technology centers and research facilities that assist states and school districts. In addition, the Department of Education will increase its efforts to promote information sharing. For example, it will sponsor national and regional conferences that give state and local education leaders an opportunity to learn from the experience of communities that are further ahead. The conferences will also promote collaboration between various state and federal initiatives to maximize the impact of state and federal investments in educational technology.

State-of-the-Art Tools

The federal government has a strong history of research and development in both learning and technology. That work has shown that all students can learn to much higher levels than we had previously expected, and led to the development of breakthrough technologies such as the Internet, high-performance computing tools, and technological tools for students with disabilities. This year, the President's Committee of Advisors on Science and Technology will issue recommendations on how federal research and development can help to ensure the development of new ways of using technology for learning, new learning materials, and new ways of measuring student progress. Based on these recommendations, federal agencies will provide funding for the highest priority areas for research and development and disseminate results.

Closing the Divide Between Technology "Haves" and "Have Nots"

The federal government can help to close the "digital divide" between affluent communities with access to technology and low-income communities where schools lack computers, access to the Internet, software, trained teachers and basic wiring. The Technology Literacy Challenge Fund, if approved by Congress, would provide resources for those communities facing the greatest challenges. In addition, many major federal education programs — including Title I of ESEA, the School-to-Work Opportunities Act, the Perkins Vocational and Applied Technology Education Act, and Head Start — target funding to low-income communities, and can invest in educational technology.

Under the leadership of the vice president, the private sector has stepped forward to help schools in the nation's 15 Empowerment Zones, which are among our most impoverished urban and rural communities. The private sector, working with Tech Corps and the Department's Regional Technology in Education Consortia, will connect every school in the Empowerment Zones to the information superhighway.

Monitoring Progress Toward Technology Goals

An essential role of the federal government in helping the nation meet the technology literacy challenge will be to monitor national progress and provide regular updates on how far the nation has traveled toward meeting the challenge. This report provides baseline data on where we are today regarding each of the four goals: the extent to which teachers are adequately trained to use technology in the classroom; the availability of modern, multimedia computers in the classroom; the percent of schools and classrooms connected to the information superhighway; and the use of effective software and on-line resources in school curriculum.

To evaluate how the nation is progressing, the National Center for Education Statistics (NCES) intends to collect data related to technology in schools through such vehicles as its Schools and Staffing Survey and Fast Response Survey System. As NCES plans for the next administration of the Schools and Staffing Survey in 1998, it is consulting with the field to determine how best to collect information about access to and use of technology in schools. Moreover, the Fast Response Survey System has been used twice in the past two years to collect information related to the availability and use of telecommunications in schools, their plans to implement or upgrade wide area connections, their access to the Internet and selected Internet capabilities, and barriers they face to the acquisition or use of advanced telecommunications. The survey system could be used to collect this information in future years. Further, under the proposed Technology Literacy Challenge Fund, each state would be required to develop its own state-specific goals and benchmarks and report annually on progress toward them.

Role of States and Local Communities

In every state, and in many local communities, there are examples of how the application of technology has transformed teaching and learning, and improved student achievement. State leaders, such as governors, state legislators, and state utility regulators, are building information infrastructures and supporting teacher professional development (see Appendix C for examples of state support for technology in education). Local community leaders, such as school district officials, school board members, educators, families, students, and other interested citizens, are developing plans to use technology in schools and are raising money to implement them.

These pioneers have a tremendous opportunity to

Until recently schools could rely on the tools they have always used — paper, pencils, and books — to accomplish their basic mission of equipping students with the skills and knowledge they need to be productive citizens. Today, that is no longer true.

— District Superintendent, Northwest Regional Forum

maximize the impact of their efforts by reaching out to those districts and communities that are not as far along. California schools that were wired on NetDay '96, for example, can help the next wave of California schools. Similarly, school districts with effective professional development or technical support programs can share these ideas with others.

Leadership and Planning

Sustained state and local community leadership will be required to meet the nation's technology goals. By putting forth compelling visions of the use of technology in education and fostering a sense of urgency, teachers, parents, educators, administrators, and policymakers at all levels can build public awareness and support for the effective use of technology in classrooms.

Leadership also means setting high standards for the results expected from the use of technology for both students and educators. Alaska, for example, considers technological literacy a content area for which it should hold students accountable.

Building and supporting the infrastructure needed to bring about the increased use of technology in schools is an enormously complex undertaking. Any effort that does not seek out the best thinking available, and that does not reach out to all members of the community will be difficult to sustain. University personnel, museum and library staff and volunteers, and members of other private or industry groups, for example, can all provide valuable expertise and are often overlooked resources.

Families of students are also valuable participants in the planning process, not only in identifying how technology can be used in the classroom, but also in how it can be used to support learning at home. Some state and community plans may include linking schools with homes, enabling students to continue learning with technology at home and parents to communicate with schools and to better participate in their children's education. Indeed, before making investments, communities will want to understand how much they will need to invest and what benefits they will likely receive.

And states and communities can assist each other in the planning process. For example, as more states and districts come on-line, they can share local and state technology plans and specific information about the challenges they face and solutions they have adopted.

Ongoing Support for Teachers

States, school districts, and schools play a critical role in ensuring that teachers receive adequate training in how to use technology to improve learning and that they receive the ongoing support they need to use technology well in the classroom. States can begin by setting high standards for teachers' skills in technology. State teacher certification requirements that ask that teachers have a working knowledge of educational technology and how to use it in the classroom to improve student achievement would send important signals to teacher training institutions and prospective teachers.

Once teachers are in the workforce, states and school districts can require and encourage ongoing training in the use of technology. For example, as part of state and local professional development strategies, states and school districts can require in-service train-

TECHNOLOGY PLANNING

The use of technology requires planning, because without certain key ingredients (such as adequate professional development and technical support) technology's benefits will probably not be realized. Here are some questions to ask while planning for the use of technology. There is no one best way to answer them, and the answers may change over time for schools and districts.

How will the technology be used? Will the uses be electronic mail, satellite-delivered instruction, access to electronic databases and libraries, multimedia software for instruction, "tool" software such as spreadsheets and word processors, access to resources for students with disabilities, or administrative uses such as record keeping, publishing, and communicating with parents?

How will the introduction of technology affect the way the school works? How will the school adjust to make the best use of technology? How can the technology be used after school and by community members in continuing education? How can technology be used to improve all aspects of the school's or district's operation?

Will school buildings need to be retrofitted? How can these costs be minimized? What features should be introduced into new buildings?

How will teachers' needs be met? Will teachers have adequate professional development and time to learn how to integrate new tools into their instructional practices? Will teachers have access to enough ongoing technical support? Should evaluation and certification criteria for teachers be changed to support the use of technology?

How can the community be involved in the introduction of technology in the school? How will members of the community be involved in the planning process? How can resources such as cable and telephone companies and community organizations be utilized?

How much will the changes cost, and what will the results be? Will the changes be worth the expense? What research exists to support the plan? How will educators know if the plan's objectives have been met?

How will decisions about purchases be made? Will these decisions be part of a larger education improvement plan in the district or school? How long will the equipment purchased remain usable? How will funds be allocated among hardware, software, training, and ongoing support? How will funding be distributed among schools? Who can give you sound advice about technology purchases?

How can technology benefit all students? How will students with disabilities benefit from the changes? How can technology benefit gifted and talented students? How can technology benefit students at risk of dropping out or who are not performing well? Will there be a standard minimal technology base in all schools?

The planning process can be difficult, but it is also vital to success. Key resources for planning include state and district technology coordinators, local telephone and cable companies, and the Department of Education's Regional Technology in Education Consortia (see Appendix D for further sources of information).

ing in technology that is both sufficiently sustained and intensive to bring teachers up to speed with this new tool for teaching and learning. States and school districts can also tie pay raises and promotions to training in technology and effective use of technology in the classroom. They also can ensure that teachers have the technical support they need by budgeting for staff to maintain equipment and otherwise provide much-needed technical support.

Teachers can often help each other learn new technological skills. For example, a trained cadre of exemplary technology-using teachers can help train and support other teachers, and, in this manner, sustain a state's efforts over the long term. Or, through the use of local or state wide networks, teachers can communicate with each other, get advice from each other on how to use technology to improve their teaching and their students' performance, and update each other on technological advances.

Finally, states and districts can allocate adequate resources to teacher training and support in the context of their overall technology budget. Today, less than 9 percent of technology funding is allocated to teacher development and ongoing support, but at least 30 percent is necessary for teachers to have the training and support they need to use technology effectively to improve student achievement.

Even the one computer I have had in my classroom for the past year has made a big difference. The computer touches students in a unique way and sparks enthusiasm for learning.

— Elementary School Teacher, Southeast Regional Forum

Modern Multimedia Computers in the Classroom

Schools, school districts, and states can pursue several creative strategies to ensure that all teachers and students have access to modern multimedia computers in their classrooms. To reduce the costs of purchasing existing technology, states can reap savings through bulk purchasing by creating master bid lists that schools and districts can use to order computers and other equipment. Schools and districts can also network computers in new ways (for example, by connecting a powerful server to a number of less powerful computers) to create cost-effective access to technology. States can also work closely with private industry to develop lower-cost computers specially designed to meet the needs of teachers and students.

Effective Educational Software and On-Line Learning Resources

States and districts have an important role to play in ensuring that effective educational software is available for students and their teachers. As more and more states and communities develop their own standards of what students should know and be able to do, the demand grows for educational software that helps students learn basic and advanced skills in all of the core subject areas. To ensure that suitable software is available, states and districts can work closely with software producers to develop software that meets the needs and goals of their students. To create a large enough market to spur the private sector to produce high-quality software appropriate for schools, states or districts may band together to support the development of high-quality software that helps to teach the basic and advanced material and skills they expect their students to know, purchase software in bulk, and tailor their procurement processes for the specifics of the software marketplace.

Today, there is already a great deal of educational software available to schools. But teachers need help in identifying which products will help them in the classroom. States and school districts can assist by evaluating software and developing lists of high-quality software for schools and teachers to use.

Adequate Financial Support and Equitable Access

While some states and communities have already

committed themselves to investing hundreds of millions of dollars to connect schools, others will need to find creative ways to redirect existing educational funds to support the use of technology in education. One promising possibility is for state leaders to take advantage of the opportunities afforded by the recent passage of the Telecommunications Act of 1996, which makes it easier for states to adopt rules that lower the costs of connections and services to schools.

Many local communities do not have the resources to reach the nation's technology goals. Recognizing this, states could distribute funds based on need or through competitive grants with preference given to the neediest districts. In many cases, state and local efforts to ensure equitable access could be enhanced through collaboration with private and nonprofit organizations and the federal government.

Role of Higher Education and Private and Nonprofit Sectors

A number of individual businesses, foundations, and colleges and universities are already making significant contributions towards reaching the nation's technology goals by supporting the improvement of state and local infrastructure, developing instructional resources, and training current and future teachers in the use of technology in the classroom. Yet, collaborative efforts — efforts in which multiple organizations pool their expertise and resources — promise to yield even greater results for schools. The success of NetDay '96, for example, was made possible only through the cooperation of several telephone, cable, hardware, and software companies and thousands of individual volunteers.

There are many opportunities for institutions of higher education as well as for the profit and nonprofit sectors to contribute to reaching the technology goals set forth in this report. For example, they could support professional development, develop instructional materials, collaborate with elementary and secondary schools, and conduct or sponsor research on the use of technology in education.

Supporting Professional Development

The colleges and universities that prepare teachers clearly play a critical role in ensuring that all teachers have the training they need to use technology effectively in the classroom to improve student learning. Teacher preparation programs can make a difference by requiring a working knowledge of technology for graduation, and by focusing on teaching *with* technology, not merely teaching about it. Colleges and universities are also important sources of expertise for in-service professional development programs that help bring teachers who are currently in the workforce up to speed in technology.

Private and nonprofit sectors can support ongoing professional development in numerous ways. For example, some corporations are developing on-line professional support networks that can provide classroom teachers with immediate help in solving an Internet glitch, provide tips on how best to find information about Walt Whitman on the Internet, or share lesson plans that effectively integrate technology in the classroom. Other corporations have developed professional development programs that provide intensive technology training to teachers and follow-up consultation once teachers are back in the classroom.

Professional organizations might support teachers by developing easily accessible electronic data banks of lesson plans tied to state or voluntary national standards, such as the widely used mathematics standards, that have been used and validated in the classroom. Professional organizations can also recognize the importance of improving teachers' skills in technology by developing awards programs that recognize teachers who effectively use technology in their classrooms.

Instructional Materials

Institutions of higher education and the nonprofit and private sectors can support the development of high-quality instructional materials in a number of ways. Software developers — whether private sector or university based — can collaborate with states and standards-setting organizations to design software that is directly linked to local curricula. They can work closely with cognitive scientists to ensure that new software is based on the best and most up-to-date research on effective teaching and learning techniques. To help schools and teachers sort through the thousands of software titles available, institutions of higher education and nonprofit or professional organizations could also work to develop methods of evaluating the

Technology is important to all the schools across the country, because without technology we'll be second all the time. We don't want to be second. We need to be number one. In order to be smarter, we need to have technology. I always say this: if you don't take risks, there is no success.

— High School Student, Southeast Regional Forum

effectiveness of software and the extent to which they are geared to particular state standards, and make that information widely available to software purchasers.

Collaboration With Elementary and Secondary Schools

Colleges, universities, research laboratories, and private companies are increasingly collaborating with schools in recognition of their civic responsibility and in efforts to learn more about how to develop effective educational technology strategies.

Examples of individual organizational efforts are noteworthy. One leading telephone company, for example, recently announced a major teacher-training initiative to which it plans to commit $150 million over five years. Another effort, that of a foundation of a hardware firm, began funding several sites with ten $2-million-a-year grants for education reform in 1994. Yet another has focused on linking schools with homes to enable parents to communicate with schools and to understand better and participate in their children's education. Grants support all aspects of education improvement, including hardware, software development, and teacher training.

Research on the Use of Technology in Education

Almost every aspect of technology in education — hardware, connections, and instructional content — is changing extremely rapidly. Today's most up-to-date computer may be surpassed by new technology in only a few years. In the next century, telephone connections to the Internet may be supplemented by wireless or cable connections or by new technology not even yet imagined. Universities, the private sector and research centers can continue to engage in and sponsor research on the use of technology in education to ensure an adequate base of research to guide school efforts.

To ensure that research addresses critical issues in educational technology, researchers can collaborate with schools and educators to focus on key issues. Depending on the needs of particular states and communities, this means developing software that reflects the most current knowledge of effective classroom practice, developing universally accessible technology that meets the needs of all learners, including those with disabilities, or developing low-cost options for hardware, networking and connections in the school setting.

Researchers can make additional strides in ensuring that the results of their work are effectively disseminated to educators and policy makers. For example, if a researcher evaluates the feasibility of a wide range of in-school networking options, evaluation results can be made available through on-line databases to other schools and districts that are trying to make their own decisions about whether and how to network their classrooms cost-effectively.

From Vision to Reality

The United States and the world are now in the midst of economic and social change every bit as sweeping as any that has gone before. It is nothing short of revolutionary — computers and information technologies are transforming nearly every aspect of American life. Continued success as a nation will depend on providing our children with the skills and knowledge necessary for high-technology work and informed citizenship.

This means that all students will have to achieve far more than they have been asked to in the past. They must be held to high standards that make clear what they should know and be able to do in the core academic subjects. And students must be afforded the opportunities provided by state-of-the-art educational technology, because we know that without those opportunities, their future hangs in the balance. Reaching the president's technology goals will ensure that technological literacy becomes the nation's "new basic" alongside reading, writing, and arithmetic. The quality of our nation's future depends on it.

All sectors of society have an enormous stake in making technological literacy a reality among the nation's students. But what remains to be done looms large. Students challenged by poverty and disability are too often denied the opportunities they so desperately need.

Indeed, the challenge articulated in this report is as much for the nation to come together as it is to bring technology to America's schools, for we will have to work together — collaborate in new ways with new partners — if we are to make this vision a reality. It will take nothing less than innovative and enterprising leadership with vision, dedication, and persistence to ensure that America's children meet the future with a wealth of opportunities and full measure of optimism. Let us provide our children with the tools they will need for life long success.

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APPENDICES

A. How This Plan Was Developed

B. Federal Support for Technology in Education

C. State Support for Technology in Education

D. Sources of Further Information

APPENDIX A

How This Plan Was Developed

Many individuals and organizations contributed to the development of this technology plan. The Office of Educational Technology played a key role throughout the planning process and in the preparation of the final report. Special thanks are due to the assistant secretaries, senior staff, and members of the Department of Education's technology team.

Seven regional forums brought together more than a thousand parents, teachers, business leaders, technology experts and researchers. These citizens submitted documents, made public statements, engaged in broad-ranging discussions, and provided us with a diverse tapestry of ideas, experiences, and concerns from regions all across America. The forums in Denver, Colorado; San Francisco, California; San Antonio, Texas; Kansas City, Missouri; Seattle, Washington; White Plains, New York; and Harrisburg, Pennsylvania would not have been possible without the assistance of the secretary's regional representatives.

The Department also wants to make special note of the suggestions of more than 400 educators and Technology industry leaders across the country who participated in a three-month on-line discussion of issues central to the plan. One unique aspect of this on-line conversation was a discussion by students organized and overseen by Montgomery Blair High School in Maryland; another was an on-line discussion for parents, directed by a parent and supported by the Consortium for School Networking. We are grateful to the suggestions from all these participants and believe this document reflects their concerns.

In addition, teams of educators and leaders from 50 states participated in the Secretary's Conference on Educational Technology, "Making It Happen," and they provided a rich source of ideas and experiences that shaped our vision and helped us articulate specific goals and action steps for the federal government, states, local communities, higher education, and the private sector.

The National Information Infrastructure Advisory Council (NIIAC) — charged with promoting the development of the Information Superhighway — produced its final report in January 1996, entitled *KickStart Initiative: Connecting America's Communities to the Information Superhighway. KickStart* and the council's deliberations provided important ideas and analysis for this plan.

Several outside organizations and contractors provided particular assistance in the development of this plan. The RAND Corporation's Critical Technologies Institute organized four workshops with leading experts and practitioners that focused on the dynamics of the software market; the barriers to professional development; the elements of planning and financing school technology and connectivity; and the impact of technology-supported student learning. More than 70 experts participated and their contributions were extremely valuable. RAND also compiled written summaries of the workshops, commissioned several additional papers, and prepared a final report on the elements of a national strategy. These reports, listed below, are publicly available. The Widmeyer Group conducted several citizen focus groups, and the American Institutes for Research assisted in the preparation of the written document. Carter/Cosgrove and Company was responsible for producing this document.

Finally, the National Science and Technology Council's Committee on Education and Training and its National Plan Working Group also made significant contributions.

* * *

The following reports of the RAND Corporation's Critical Technologies Institute are available by contacting RAND distribution services at (310) 451-7002 (voice), (310) 451-6915 (fax), or order@rand.org (electronic mail). They are also available online at http://www.ed.gov/Technology/Plan/.

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APPENDIX B

Federal Support for Technology in Education

AGENCY	RESPONSIBILITIES
Department of Agriculture	The Rural Utilities Service administers grants and loan programs to assist rural and remote communities with the development of their telecommunications infrastructure. The Distance Learning and Medical Link Grant Program supports telecommunications links for rural schools to provide students with access to advanced courses and other distance learning opportunities. Technical assistance and advice for rural communities are provided through the Extension Service.
Department of Commerce	The Telecommunications and Information Infrastructure Applications Program (TIIAP) awards matching grants to state and local governments, as well as nonprofit organizations, to finance their access and use of telecommunications. These grants are intended to demonstrate the potential impact of telecommunications networks and extend these networks into currently underserved areas. The Public Telecommunications Facilities Program awards grants to public broadcasting and other noncommercial entities for acquisition of telecommunications equipment. Of 142 awards made with FY 1995 funds, 32 supported distance learning, some of which involved elementary and secondary schools.
Department of Defense	The Department of Defense conducts ongoing technology-based training and research and development for the instruction of military personnel and students in its K-12 schools. It is also conducting several targeted programs such as a research and development initiative on information-based technologies to dramatically improve learning and productivity in both professional development of military personnel and education with the Department's K-12 schools. Another program involves the Department of Defense schools as an exemplar for how technology can be used to substantially improve educational outcomes by integrating existing and planned technology, such as instructional software, into school programs. Another program works with Department-run schools as national models to effect systemic reform through the integration of technology.
Department of Education	The Department of Education focuses on leadership activities, including technology planning, K-12 school reform, evaluation, research and development, and dissemination of technology for learning. The Regional Technology in Education Consortia (R*TECs) and other technical assistance services provide technical assistance and support professional development related to educational technology. Educational services for special populations, including low-income students, students with limited proficiency in English, and children with disabilities, are also provided. The National Challenge Grants for Technology in Education fund several demonstrations of high-intensity use of technology in education. The Star Schools grant program supports distance learning projects linking students and teachers over large distances using telecommunications technologies, such as satellites and fiber optic networks.
Department of Energy	Activities include the development of network technology; technical assistance to selected school districts; teacher professional development; and research & development through HPCC (see below).
Department of the Interior	The Bureau of Indian Affairs funds K-12 education on Indian reservations, including piloting innovative uses of technology.
Department of Labor	The Department of Labor provides leadership for training and funds state and local job training activities.
Federal Communications Commission	The FCC sets interstate policies on telecommunications and information infrastructure, with a focus on affordable telecommunications access for schools, libraries, hospitals, and clinics.
High-Performance Computing and Communications Program (HPCC) *(Interagency effort)*	HPCC is an ongoing joint research & development interagency effort to create an integrated system of high-capacity telecommunications networks that would link business, government, education, health care, and the public. Research & development areas include high-speed networking, simulations, virtual reality, artificial intelligence, and digital libraries. Aspects of these efforts include projects to expose K-12 students to high-performance computing and create resources for teachers.
National Aeronautics and Space Administration (NASA)	NASA's Educational Technology Program focuses on developing of high quality, affordable learning tools and environments through the Classrooms of the Future program, which develops applications for aerospace education. Demonstrations of innovative technology and networking applications include KidSat which permits students across the country to interact in shuttle missions and download images in real time via the Internet. NASA also funds the development of network technology, teacher professional development, and research & development through HPCC (see above).
National Science Foundation (NSF)	NSF supports technology innovations and reforms that improve mathematics, science, and technology education, and funds research & development projects through HPCC. The Networking Infrastructure for Education Program develops model applications of telecommunications technology supporting school restructuring, professional development of teachers, and increased student achievement. The Educational System Reform program (Statewide Systemic Initiatives) funds several state projects that target the application of technology. NSF funding was instrumental in the development of the Internet.

APPENDIX C

State Support for Technology in Education

Frequently motivated by participation in the Goals 2000: Educate America Act, many states have placed technology at the center of their efforts to develop high standards for what students should know and be able to do. Without question, most states have made impressive contributions to upgrading their schools' technology base, but more must be done to realize the president's technology goals. Simply as an illustration of the magnitude, diversity, and scope of ongoing state efforts, the following table outlines current state support for technology in education. This table was developed in the spring of 1996 with the help of the Software Publishers Association.

STATE SUPPORT FOR TECHNOLOGY IN EDUCATION

ALABAMA

Planning: The Governor's Information Technology Commission was established by Governor James in October 1995. The purpose of the commission is to develop guidelines, policies, and equipment standards for information systems that will be followed by state executive agencies, public schools, and state education agencies.
Services: The state has put into place a scholarship program that pays partial tuition for teachers willing to take three technology courses as part of their master's degree program.

ALASKA

Planning: Alaska is finalizing its statewide plan for educational technology funded by Goals 2000. The Governor's Telecommunications Information Council has been charged with developing a statewide telecommunications plan. A statewide conference is planned in 1996 to foster cooperation between the Alaska Department of Education, colleges and universities, local and long-distance telephone companies, cable companies, public broadcasters, legislators, and other organizations, and to develop specific recommendations for a statewide plan.

ARIZONA

Planning: The Arizona Department of Education established an outline for technology planning in 1990-91. Many school districts have used it as their primary planning guide. The Arizona Educational Telecommunications Cooperative also issued a series of white papers and reports entitled "The Last Mile," which outline telecommunications infrastructure and issues in the state as they relate to K-12 education.
Infrastructure: Currently, the Arizona Department of Education supports over 3,000 K-12 Internet users via direct and dial-up connections. Further, in an initiative to foster rural school connectivity and technology use, 50 Cisco 2511 routers were distributed, with training and support for connections. More than 600 sites will be connected through this initiative.
Funding: A legislative appropriation request for $6.8 million is currently pending. The funds are intended to enhance telecommunications and connectivity at each school site in the state.

ARKANSAS

Planning: A state technology plan will be considered in the 1997 legislative session. A goal of connecting all school buildings to the Internet by 1998 has been set. A non-profit organization (Project IMPAC) is helping school districts incorporate microcomputers into the classroom and coordinate technology efforts. The state has set guidelines for Internet usage policies for school districts, and school district technology planning is being coordinated with the Arkansas Department of Education.
Infrastructure: The Arkansas Public School Network (APSCN) provides Internet services.

CALIFORNIA

Planning: A state plan is already in place, and each of the state's eleven county office of education regions has recently completed plans as well. In January 1996, the state began implementing the California Technology Assistance Project, which allocates funds to each of these regions rather than funding statewide technology programs. By March 1996, the California Education Technology Task Force, composed of over 50 members selected by State Superintendent of Public Instruction Delaine Eastin, will prepare an action plan for advancing the use of technology in California schools.
Funding: In July 1995 the State Board approved $13.4 million for educational technology, which was recommended in the Education Technology Act. Of that, $6.5 million will be allocated through a competitive grant, and the remaining funds will be allocated to existing technology projects. The 1995-96 budget includes a $279 million, one-time block grant for instructional materials, deferred maintenance, technology, and other non-recurring costs. The 1995-96 budget also includes a $10 million educational technology initiative to refurbish and upgrade used or donated computers. Governor Wilson's budget proposal for 1996-97 contains $100 million of additional current-year funding for educational technology for distribution on a per-student basis. In 1994, Pacific Telesis was directed to distribute $35 million in rate overcharges. This $35 million may be made available to K-12 schools following a variety of hearings and court decisions.

COLORADO

Planning: Colorado's state plan, "A Vision for Technology in Colorado Education," was released in 1995 and focuses on increasing the use of state-of-the-art technologies and on staff development. Eight goals to achieve the vision for technology in Colorado education have been identified. Each goal has three or more objectives related to increasing integration of technology into instructional and administrative applications. Work has begun on priority tasks that will be achieved during the 1995-96 and 1996-97 school years.

Funding/Regulation: Educational technology is getting a great deal of interest in both the legislative and executive branches of government with numerous bills being submitted to fund technology initiatives for pre/K-12 and higher education. In response to this, the pre/K-12 and higher education communities are working together to design a statewide telecommunications network and grant program for "classroom technologies." The Colorado Public Utilities Commission and US West reached an agreement in 1995 resulting in US West's allocation of over $5 million for community-based telecommunications projects for pre/K-12, higher education, health care, and libraries. Having cleared judicial tests, funds will be distributed shortly. Legislation was passed during the 1995 legislative sessions that allows local exchange carriers to provide discounted rates for interactive video applications for distance learning.

CONNECTICUT

Planning: Governor Rowland declared November 1995 "Technology Month," and set a goal of every school being connected by the year 2000. A private firm, the Center for Educational Leadership and Technology, has helped develop a statewide plan for technology that was approved by the State Board in December 1995. The Educational Telecommunications Services Task Force has been created to recommend funding sources and mechanisms and submit a plan to the legislature in 1996. The Joint Committee on Educational Technology was charged to make recommendations for the coordination of educational technology.

Funding: In 1995, a $10.4 million competitive grant program was initiated from bond funds to assist local and regional school districts and regional educational service centers to support activities related to upgrading electrical systems, wiring buildings, and acquiring equipment.

DELAWARE

Planning: The Delaware Educational Technology Plan is designed to link every classroom in the state with telecommunications access; set standards for school library, media, and technology centers; define physical plant requirements; develop long-range professional development strategies; and set goals for annual funding allocations for technology.

Services: The Delaware Department of Public Instruction provides technical assistance in linking the state content standards in English/language arts, mathematics, science, and social studies. The State Office of Telecommunications Management provides high-speed, direct-connection lines through the state telecommunications system to all secondary schools. Elementary schools will be connected by the end of the 1995-96 school year. The State Office of Telecommunications Management in cooperation with the Department of Public Instruction provides Internet connections to all educators free of charge.

Infrastructure: The Delaware Center for Educational Technology is charged with creating a modern technology infrastructure in Delaware's public schools that will bring fiber optic, coaxial, and copper wire to every classroom in Delaware within the next three years.

Funding: The state legislature has committed $30 million over three years to the Delaware Center for Educational Technology to fund the infrastructure initiative. Federal Goals 2000 funds have been used for technology planning and professional development, and to subsidize the cost of computers in poorer districts.

DISTRICT OF COLUMBIA

Planning: The District of Columbia Public Schools (DCPS) Board of Education approved the Technology Plan 2000 for School Years 1991-1996 in 1991.

Services: The Center for Innovative Technology and Training (CITT) was established for the purpose of providing state-of-the-art ongoing and recurrent technology-related training for hardware and software. The services provided by CITT will enable DCPS personnel the necessary support services to meet their technology-related instructional and management needs.

Infrastructure: A major thrust in the DCPS is to integrate the use of information technologies, telecommunications networks, and other learning technologies into curriculum and instruction. The Office of Management Information Services (MIS) plans to provide the necessary operating system hardware, software, and connectivity to give all elementary schools high-speed direct access to the DCPS wide area network (WAN) and to the Internet.

Funding: The three units will pool funds from their budgets to make the above hardware and software purchases a reality. A proposed three-year budget totals nearly $9 million. Local schools will use their own budgets to acquire hardware through Title 1 funds and other sources.

FLORIDA

Planning: Florida developed its first technology plan, "Schoolyear 2000," in 1989. The Center for Educational Leadership and Technology, a private firm, has recently conducted a study of Florida's technology initiatives to guide development of a comprehensive instructional delivery system.

Infrastructure/Regulation: The Educational Facilities Infrastructure Improvement Act was created to ensure access to advanced telecommunications services.

Funding: The Florida legislature provided $117 million for technology in 1995.

Services: The state uses a venture capital fund to support private sector development of software linked to the state's content standards. Florida schools receive a discount on the software, and the state receives royalty payments for sales outside the state.

GEORGIA

Planning: Georgia's state plan for technology, "Instructional Technology Guidelines for the State of Georgia," is being updated by an Instructional Technology Task Force. The 1995 legislature enacted legislation to create a new Educators' Technology Training Commission to undertake a comprehensive study of the state's need for training educators in the use of technology. Its report is expected shortly.
Funding: The budget to school systems for educational technology totals $50 million. It includes $3 million allocated to alternative schools, $500,000 for an Internet project for gifted students, and $1 million for educational technology at the Department of Children and Youth Services.

HAWAII

Planning: "The Hawaii Technology Plan" has recently been completed. It includes strategies and benchmarks, and describes state activities to be undertaken in support of the plan.
Infrastructure/Regulation: Hawaii NetDay was launched on January 11, 1996. The state has used its regulatory authority over cable television to ensure that every school has a cable link, and in 1994, the Hawaii Education and Research Network received $2 million from the National Science Foundation to provide training on the use of the Internet to every school through coaxial cable.

IDAHO

Planning: The state's education plan, "Schools for 2000 and Beyond," developed in 1992, includes a plan for "converting Idaho schools into high-tech institutions," focusing on equipment, infrastructure, and training for school staff. While never funded, the plan created momentum for technology use in schools. The legislature developed the "Idaho Education Technology Initiative" in 1994, creating a 15-member Council for Technology in Learning with membership spanning elementary and secondary education, higher education, the private sector, libraries, legislators, and broadcasting authorities.
Funding: Schools received $10.4 million under the Idaho Educational Technology Initiative of 1994 for technology in the classroom. A competitive grant program for over $3 million provided other funds to schools.
Infrastructure: All Idaho schools should be connected within five years.

ILLINOIS

Planning: The Illinois State Board of Education's Goal 5 reads, "All Illinois public school students will attend schools which effectively use technology as a resource to support student learning and improve operational efficiency." A number of activities have been initiated at the state level to support this goal, including the launching of the Educational Technology Hubs, the deployment of a statewide computer network, the establishment of Internet "points of presence," grants to 292 schools for on-line curriculum-projects, grants to 98 schools and 4 museums for "Museums in the Classroom," strategic technology resources for 36 economically challenged schools, and the development of the Illinois K-12 Plan for Information and Technology.
Funding: In FY96, lawmakers appropriated $15 million for projects that use technology and telecommunications to improve student learning.

INDIANA

Planning: The state requires that school districts submit five-year technology plans prior to spending capital projects funds and technology funds. The new Indiana Technology Fund provides $10,000 grants to be used for planning by those schools qualifying for major funding.
Funding: Indiana allocates $4 million annually to the Educational Technology Fund to support three programs: the Buddy System Project, the 4Rs Program for early grades, and Access Indiana. The Indiana Technology fund is currently being supported by $20 million from gaming revenues. It funds Internet connections and the expansion of the Buddy System Project. The School Technology Advancement Account supports one percent interest loans of $5 million annually. The Computer Learning and Training Account, currently funded at $1.6 million annually, has supported a professional development program for teachers since 1983.
Infrastructure: Intelenet Commission manages a fiber-optic network that connects 256 institutions of higher education, government agencies, and schools throughout the state. As a result of the Indiana Utility Regulatory Commission's approval of an Ameritech regulatory reform plan, Ameritech is investing $120 million over a six-year period to extend an advanced communications network to every interested school, hospital, and major government center in its Indiana service area. This network, which includes broadband voice, data, and interactive video applications, could link as many as 1,700 schools.
Services: IDEAnet, a statewide telecommunications network, is available to all educators in the state through an 800 number.

IOWA

Planning: "Education is Iowa's Future," a statewide plan for education, directs the state Department of Education to take "a leadership role by developing and communicating a compelling vision for using technology to transform the teaching and learning process, by facilitating the acquisition of technologies and providing appropriate staff development."
Infrastructure: Iowa has developed the Iowa Communications Network, an interactive fiber-optic network designed to link all of Iowa's K-12 schools, education agencies, community colleges, colleges, and universities. Parts I and II of the network, creating a statewide backbone, are complete. Part III, connecting all school districts, area education agencies, and some public libraries, will be completed in the next four years.
Funding: In 1995, the legislature appropriated $36 million for FY96 and FY97 for operating and completing Part III. They are also completing work on a bill that will appropriate $150 million over the next five years to develop and fund instructional technology in public schools.

KANSAS

Planning: The Kansas State Board of Education, using a team of 20 technology volunteers from school districts and higher education, created a technology planning guide for distribution to schools in Kansas. The planning guide contains a reference section for resources available by mail as well as electronically, an appendix identifying terms commonly

used in technology discussions, and the three stages for developing and implementing a technology plan. The first stage identifies six steps that can provide a solid foundation for building a local plan.
Funding: No state funding is available.

KENTUCKY

Planning: The "Kentucky Master Plan for Educational Technology" specifies connections for all schools, classrooms, and school offices in the state, and recommends connections to the home for educational use. The plan calls for a telephone in each classroom, video in every classroom, a computer for every six students, and a computer for each teacher. The total cost is expected to be $560 million over six years.
Funding: Kentucky provided $20 million from its educational technology trust fund for the 1994-95 school year. So far, a total of $195.4 million in state and local funds has been spent to implement the master plan.
Infrastructure: All 176 districts are now online through an instructional and administrative network via T1 lines.
Services: KETS, a statewide network of educational television, public libraries, and other organizations, provides technical assistance, professional development for teachers, statewide procurement contracts for hardware and software, and other services to school districts, as well as funding for instructional technology. The state provides recommended lists for software, and districts can use textbook dollars to buy recommended software products.

LOUISIANA

Planning: The Louisiana Educational Technology Plan for Grades K-14 is being integrated into the state's Consolidated Plan to Improve Education in Louisiana. The Consolidated Plan will bring together planning efforts involving Louisiana Goals 2000, the Improving America's School Act, the School-to-Work Opportunities Act, Louisiana Systemic Initiatives Program (LaSIP), the Louisiana Networking Infrastructure for Education (LaNIE), and other technology initiatives.
Infrastructure/Regulation: A multi-protocol, wide area network called LaNET is available within the state to educational institutions, political subdivisions of the state, and other qualifying organizations. LaNIE, the Louisiana Online University Information Systems (LOUIS), and the Louisiana Library Network (LLN) use LaNET to provide Internet access to schools and libraries at numerous sites throughout the state. Louisiana's Public Service Commission has established a special telecommunications tariff for education, which significantly reduces the rates charged to schools and libraries. Louisiana has a six-station public television network which reaches most of the state. Every school district in the state has at least one satellite dish. Several school districts also program their own cable access channel.

MAINE

Planning: Several statewide planning efforts are underway.
Infrastructure/Regulation: Maine's Interactive Television System links universities, community colleges, and high schools to provide distance learning courses across the state. The Maine Public Utilities Commission has approved a plan for developing a school and public library network allowing high-speed access to each of 1,000 facilities for Internet, e-mail, and other telecommunications projects. The cost will be born by NYNEX as a result of a $20 million overcharge settlement. The first phase of this five-year project begins in April 1996 with the formation of an oversight board.
Funding: The governor signed legislation in July 1995 that authorizes a general bond fund issue for $15 million to establish a distance learning network. The bond referendum was approved by voters in November 1995. The funds will be made available after July 1, 1996. The funds will provide the equipment to connect to the network, but not the monthly line charges. Of note, school districts are required to develop a plan for use of the network to participate.

MARYLAND

Planning: In January 1995, the statewide Maryland Plan for Technology in Education was accepted by the Maryland State Board of Education. It is now providing the basis for planning and decision-making related to technology in education at the state level and, in many cases, at the local school system level as well. A committee on technology in education has been established to provide direction to and support the implementation of all the Technology Plan activities. The committee is chaired by representatives from all stakeholder groups throughout the state. As called for in the plan, a statewide technology inventory has been completed for each school in Maryland and results are now being compiled.
Infrastructure/Regulation: The Bell Atlantic Network provides full-motion, interactive video and audio for up to four locations simultaneously. Bell Atlantic agreed to donate classroom equipment for 270 schools, community colleges, universities, and cultural institutions in Maryland. Each site, however, must pay very high long-distance fees for statewide broadcast. At this time, the network cannot be used for data transfer. A state information technology board is currently investigating options for setting up a true statewide network infrastructure that will handle voice, video, and data efficiently throughout the state.
Funding: The governor in his FY97 budget has proposed a multiple-year initiative that would provide schools in Maryland with a complete wiring distribution system and some hardware, software, and funds for staff training in order to connect classrooms to information and communication resources. This budget request will be considered by the state legislature in 1996.

MASSACHUSETTS

Planning: Massachusetts completed a comprehensive study for educational technology in 1994 known as Mass Ed Online. The state has started implementing two educational technology initiatives: (1) Upgrading the existing education network into a statewide client server network with full access to the Internet (Mass Ed Online LearnNet - MEOL). The state is advocating for a distributed network system with MEOL as the statewide network backbone. (2) Working with schools in devel-

oping local technology plans to support education reform. Plans will include the use of technology for teachers and students in curriculum; professional development in educational technology; use of technology in administration; capital expenditures; and other areas. All technology initiatives are integrated as line-item initiatives in the state's five-year (80-initiative) master plan that includes five-year state appropriations projections.
Funding: On October 18, 1995, Governor Weld submitted to the legislature The Education Technology (ET) Bond Bill seeking $60 million in bonded spending to provide the Commonwealth's learners, teachers, and administrators with direct and indirect grants, services, and equipment.

MICHIGAN

Planning: The state government is planning for the creation of a Michigan Information Network — a "virtual network" that would ensure the availability of high-speed, high-quality voice, video, and data communications for K-12 schools, community colleges, universities, libraries, medical facilities, governmental units, private businesses, and the general public. Also, the State Board of Education is on record as supporting the use of technology in education through the 22 recommendations in its five-year State Technology Plan.
Infrastructure/Regulation/Services: The Michigan Telecommunications Act was recently amended and reauthorized for five more years. The law emphasizes the provision of most telecommunications services in a competitive market, and includes a section allowing educational institutions to operate distance-learning networks essentially free of regulations. According to specific criteria, most educational institutions may now sell excess telecommunications capacity, up to 25 percent of the institution's total capacity. The Michigan Department of Education communicates extensively with educational institutions and citizens via Internet-based Gopher and World Wide Web servers.
Funding: One-time grants totaling approximately $10.5 million were awarded to two statewide and six regional projects in 1995 by the Michigan Public Service Commission — the result of a sharable earnings case involving Ameritech. The largest of the grants — to Merit Network, Inc. — has ensured local dial-in access to the Internet for every school in Michigan. Efforts to establish long-term support for the program are underway. Ameritech matched those funds with dollars of its own to create a program known as "Education Avenue." It provides discounts for schools to gain direct connections to the Internet.

MINNESOTA

Planning: A statewide technology plan is being developed by a task force established by the Minnesota Department of Education. The Minnesota Education Telecommunications Council must recommend to the legislature by December 1996 a long-term governance of state and regional telecommunications systems.
Infrastructure/Regulation: MN H4, the 1995 K-12 education finance bill, establishes a statewide telecommunications network for learning.
Funding: $2.7 million has been appropriated for the "Instructional Transformation through Technology Grants Program" in 1996 and 1997. The legislature also appropriated $5.4 million over the 1996-97 biennium for this program. In addition, the Department of Children, Families and Learning supports the InforMNs Project, a joint effort between the Department and several other organizations to provide access to the Internet for schools. This program is funded at $500,000 in FY96.

MISSISSIPPI

Planning: The Mississippi Master Plan for Educational Technology was adopted by the statewide Council for Educational Technology and the State Board of Education in October 1995. The plan focuses on the infusion of technology into classrooms to promote higher-order learning processes by students and to ensure equitable learning opportunities for all Mississippi citizens. The plan also establishes technology standards for teachers and outlines the development of the state educational backbone.
Infrastructure: Based on the outline in the Master Plan, the Department of Education will connect all of the state's school districts together via the Bell South frame relay network. The network is scheduled to be completed by January 1997. Partners include the community and junior Colleges, the institutions of higher learning, the Mississippi Authority for Educational Television (ETV), and the Mississippi Library Commission. Applications that will run on the network include e-mail, access to the World Wide Web and the Internet, and the Mississippi student level database system that will provide for transfer of student records among school districts, community colleges, and institutions of higher learning. The Fibernet 2000 project, sponsored by Mississippi ETV and the Department of Education, is being expanded through a U.S. Department of Education Star Schools Grant to provide two-way audio and video instruction in every county in the state.
Funding: The Technology Enhancement Act of 1994 is providing $26.8 million to local school districts for implementing their approved local technology plans. Plans must follow the guidelines set aside in the state technology plan and must set aside 20 percent of their funds for technology professional development. By the end of the summer, over 3,000 teachers will have been trained to use technology in their classroom.

MISSOURI

Funding: Since 1988, Missouri has used an earmarked tax on videotape rentals to provide funding for satellite dishes on schools, satellite course fees, laserdisc players, and other educational uses. Revenue is about $2 million per year. Since 1994, lottery funds have provided approximately $5 million for schools to acquire technology. In 1995, an additional, one-time $5 million was provided for technology acquisition. Missouri also provides funds to support the use of vocational technology.
Infrastructure/Regulation: The Missouri Department of Elementary and Secondary

Education is in the second year of a three-year plan with the Missouri Research and Education Network to connect schools to the Internet.

MONTANA

Planning: A state plan is being developed by a Technology Task Force jointly appointed by the Governor and the State Superintendent. Requirements for the technology plan include, describing the requirements for introducing state-of-the-art technologies into the classroom and school libraries, and how the state education agency will apply the use of technology to meet the needs of children from low-income families.
Infrastructure: SummitNet, the state and county government network backbone authorized by the legislature in 1994, is providing connections to each county seat, but not every school district. SummitNet is being augmented by Network Montana, a $2.56 million NSF grant to the University of Montana.
Funding: The state provided $100,000 for technology in 1995.

NEBRASKA

Planning: A state pre/K-12 technology plan has just been completed. This activity was done under the supervision of the Technology Consortium, an advisory committee to the State Board of Education. The State Board approved the mission statement, belief statements, and objectives of the plan in February 1996.
Infrastructure: State legislation provided taxing authority to intermediate service units to set in place an education network. This was completed in 1995. State funding was authorized to provide grants to schools for connecting to the Internet and for installing local area networks. All schools should be on or have access to the Internet by the end of the 1996-97 school year. State funding continues to be provided for establishing interactive distance learning school district pods. It is anticipated that all public school districts will be networked via the pods within the next three years.
Services: A concerted effort is now being made to provide inservice and training on the use of technology in learning to existing teachers via the intermediate service units and through the establishment of minimum competencies for teachers.

NEVADA

Infrastructure/Regulation: The Nevada School Network currently provides full Internet access to the two large urban school districts and four of fifteen rural districts.
Funding: The legislature created the Trust Fund for Educational Technology in July 1995, to be administered by the state superintendent. The legislature passed SB204, which appropriated $500 million to the University and Community College System Network to enhance the network and $400,000 to the Department of Education to connect individual schools to the network. The bill requires that the University and the Department work cooperatively to accomplish those purposes.

NEW HAMPSHIRE

Planning: A technology committee composed of Department staff, teachers, administrators, and service providers is currently drafting guidelines for local development of technology plans. All School Administrative Unit (SAU) offices are now accessing the Internet to communicate with each other. The next stage of the plan includes the transfer of files between the SAUs and the Department.
Services: Several partnerships with business and industry have provided support to the program. Extensive training has been made available though this collaborative effort.

NEW JERSEY

Planning: "Educational Technology in New Jersey: A Plan for Action" was completed in the spring of 1993. The New Jersey Department of Education has developed technology specifications for school facilities. The state's core curriculum content standards (incorporating instructional technology in seven content areas) were proposed for adoption by the New Jersey State Board of Education in February 1996.
Funding: $1.3 million was appropriated by the state for four competitive grant programs that establish model distance learning sites. The state's FY97 budget includes $10 million for educational technology entitlement grants to every school district.
Services: The New Jersey Department of Education funds and coordinates pilot site activities in 19 districts and 2 consortiums to create models of technology implementation for statewide infrastructure. The state provides Internet access via business partnerships. The state's home page (http://www.state.nj.us) includes clearinghouse information.

NEW MEXICO

Planning: The state educational technology plan was adopted June 30, 1995. It defines a standard for broadband classroom connections and recommends equal funding for every child. As of December 1, 1995, all 89 school districts have a state approved strategic plan for integrating appropriate educational technology. During the 1996-97 school year, New Mexico will create a special fund to stimulate locally developed and state-approved technology plans.
Funding: For the 1995-96 school year, funding for technology included a $9.50 per student categorical appropriation from the legislature, with an average local match of $114 per student.
Services: State-funded teacher training sessions were planned for March and April of 1996, with support from the Los Alamos National Laboratory.

NEW YORK

Planning: The New York State Board of Regents approved the Long Range Plan for Technology in Elementary and Secondary Education in 1990. The plan is being updated with participation from key stakeholders to reflect the use of technology, raising standards, and the implementation of new curriculum frameworks. A Regents Policy Council on Telecommunications and Information Technologies has been established to provide a forum for discussion for state business leaders and policymakers from state and federal governments.
Services: A model schools program exists to provide K-12 teachers with in-service and pre-service opportunities to expand their knowledge and skills by integrating technology into classroom practice.

NORTH CAROLINA

Planning: A state instructional technology plan was completed in 1994.
Infrastructure/Regulation: The state is building a comprehensive infrastructure for education, the North Carolina Information Highway.
Funding: The North Carolina Instructional Technology Plan includes $381 million over a five-year period. Forty two million dollars was appropriated for the 1995-96 school year to begin implementation of the plan.

NORTH DAKOTA

Planning: The Educational Telecommunications Council continues its statewide planning activities in cooperation with the Department of Public Instruction and the Goals 2000 panel. Funding has been provided for local, regional, and statewide planning efforts. An updated plan will be presented to the legislature in the spring of 1996. Increased emphasis on training, accessibility, and equity will be reflected in this update.
Funding: The state continues to provide grant funds and ongoing support for technology initiatives across the state.
Services: Partnerships with the North Dakota state university system and the Department of Public Instruction have created two statewide programs: The Center for Innovation in Instruction, which provides technology-related training and technical assistance, and SEND-IT, which is the state's K-12 computer network and Internet gateway.
Infrastructure: The state university system operates the Interactive Video Network (IVN), which provides interactive statewide video conferencing and university level courses. IVN is also interconnected with three of the state's K-12 interactive video clusters. These clusters involve 100 of the state's 240 school districts. The state's PBS affiliate, Prairie Public Broadcasting, has established, with assistance from the state and the U.S. Department of Agriculture, a statewide system of 60 satellite uplinks and downlinks.

OHIO

Funding: The State Board of Education adopted a technology plan in 1992. In 1994, the state launched a five-year, $95 million set of bond issues to support educational technology. These funds will be used to wire every classroom in the state to support voice, data, and interactive video communications. Almost half of these funds will support equipment purchases for the poorest 25 percent of schools. In 1995, Governor Voinovich approved the SchoolNet Plus program, which provides $125 million for professional development for teachers and the purchase of equipment in grades K-4. An additional $275 million has been included in the FY97-98 capital appropriations bill to be considered in January 1997.

OKLAHOMA

Infrastructure: OneNet is providing the telecommunications infrastructure for the state. Thirty-three hub sites have been established, connecting 82 percent of the population.
Services: The state is providing $6 million to be used to develop the 33 hub sites that will allow for data and video connections for schools, government agencies, and libraries. A U.S. Department of Commerce TIIAP grant of $1.5 million will be used to develop approximately 15 community telecommunication centers. Southwestern Bell will provide $1.4 million for an additional 14 sites.

OREGON

Planning: "The Role of Technology: A Plan to Support the Oregon Department of Education and 21st Century Schools" was released in 1992, with a series of recommendations.
Infrastructure: The Oregon Public Education Network, the result of grass-roots contributions and state support, connects schools to the Internet and is rapidly expanding.

PENNSYLVANIA

Planning: In February 1996, Governor Ridge announced a three-year $121 million initiative entitled "Project Link to Learn." The plan calls for establishing a statewide network to be called the Pennsylvania Education Network (PEN). It calls for networking K-12 public schools and higher education institutions together, and for providing training for teachers to learn how to use technology to complement and enhance the curriculum.
Funding: The first component of the initiative targets $100 million over a three-year period to improve the basic infrastructure capabilities of public K-12 schools. The second component of the initiative directs an additional $500,000 to poor and rural school districts to purchase satellite technology and increase interactive video conferencing capabilities. The third and final component directs $21 million to institutions of higher education, including community colleges, for the planning, design, and implementation of the PEN.

RHODE ISLAND

Planning: The Rhode Island Statewide Technology Plan, completed in December 1995, has been submitted to the Board of Regents for Elementary and Secondary Education for approval. It includes recommendations for an educational networking infrastructure, professional development strategies, curriculum integration, and funding.
Funding: Funding has not been addressed in any recent legislation. Local districts and philanthropic foundations have provided significant funding.
Infrastructure: A statewide network, RINet, has been developed by the Rhode Island Department of Education, the University of Rhode Island, Brown University, state libraries, and WSBE public TV. Dial-up modem banks provide toll free access from anywhere in the state. Direct digital connections to 17 of 36 school districts provide a high-speed backbone which is still expanding. The Department of Education provides free accounts for all educators.
Regulation: A recently submitted data access plan for education by the state's sole telecommunication provider, NYNEX, to the Public Utilities Commission, will provide $8 million worth of carrier services for the educational state network over the next 5 years. Acceptance is pending.

SOUTH CAROLINA

Planning: The South Carolina Educational Technology Plan, "Connecting South Carolina to the World" was released in November 1995.
Funding: South Carolina has a state foundation that raises funds for technology.

SOUTH DAKOTA

Planning: While several educational organizations have pursued technology planning activities, no statewide technology plan has been developed.
Funding: South Dakota does not have a specific state appropriation that supports year-to-year educational technology expenditures. Current efforts in educational technology are funded by a diversity of federal, state, local, and grant resources.
Services/Infrastructure: South Dakota has established a statewide, non-profit project for the purpose of providing leadership and technical assistance regarding technology applications for schools. The project operates a statewide electronic communication system for schools referred to as the Rural Development Education Network (RDE-Net). In addition, the state operates the Rural Development Telecommunications Network (RDTN) that services education as well as health, government, and business. The RDTN includes 18 two-way interactive sites and more than 60 one-way video and two-way audio sites. Nearly all of the 60 one-way sites are in school settings.

TENNESSEE

Infrastructure: The state has equipped every school library and every technology coordinator with text-based Internet, and additional funds have been allocated to upgrade to graphics and connect all 1,554 schools by the fall of 1996.
Funding: Since 1993-94, the state has provided a total of $98 million for educational technology, which includes $74 million for teacher training, state-of-the-art technology in 4,800 "21st Century classrooms," and yearly training, state salary support, and benefits for local technology coordinators.
Services: The Governor has directed non-teaching state employees with teaching certificates to substitute-teach for five days during the 1995-96 school year, creating a pool of days that can be used for teacher training. The Tennessee Department of Education runs a statewide technology conference each spring for teachers and administrators.

TEXAS

Planning: Texas' first state technology plan was released in 1988. It provided a framework to guide the state regional education service centers and school districts in meeting educational needs through the use of technology. Several progress reports have been developed to provide the status of the implementation of the original plan. In the 1995-96 school year, a task force was appointed to review the plan. The Texas Education Code for "adopting" textbooks and other instructional materials was changed in 1995 to include technology-based materials. The process now allows schools to select from lists of conforming, non-conforming, and open materials. This change makes it easier for schools to use textbook funds to purchase software and other electronic materials.
Funding/Infrastructure: All school districts in Texas are eligible to receive a technology allotment, currently $30 per student, for purchasing electronic textbooks or technological equipment that contributes to student learning, to pay for training educational personnel directly involved in student learning, and to provide access to technological equipment for instructional use. Technology allotment funds were first made available to schools in 1992. As a result of the 74th legislative sessions, the district technology allotment was rolled into the State Textbook Fund. Other state technology initiatives are funded from the newly established Telecommunications Infrastructure Fund. The Fund, totaling $150 million per year for 10 years, is composed of the telecommunications utilities account and the commercial mobile service providers account.
Regulation: House Bill 2128 provides for a measure of deregulation for telephone companies including distance insensitive rates for high-speed (T1) circuits. HB 2128 also created a nine-member board to oversee the expansion of the telecommunications infrastructure of public schools, non-profit hospitals, colleges, universities, and libraries. In addition, previous legislation allows districts to receive a 25 percent discount on tariffed rates.

UTAH

Planning: School districts are required to write five-year plans with annual updates before legislative allocations are distributed. The governing committee represents state government, public and higher education, local school districts, and business and industry. There is excellent collaboration between public and higher education.
Infrastructure: Utah has been aggressive in building a statewide infrastructure to improve student achievement through integration of technology into the teaching and learning process. This infrastructure includes hardware, software, and broadband capabilities. Every public K-12 school in the state will be connected to the Internet by the 1997-98 school year.
Funding: To date, the state has allocated over $70 million for K-12 educational technology, two-way interactive distance learning capability and Internet connectivity. It is anticipated that at least $33 million more will be allocated this legislative session.
Services: UtahLink (http://www.uen.org/UtahLink.html) is the state's computer-based service, which provides a menu of on-demand electronic educational materials and informational resources.

VERMONT

Planning: The state has developed an information technology plan. Using capital funding to build telecommunications infrastructure, the Vermont legislature is working to connect schools to the Internet. More than 100 public schools are being connected to the new "K-12 Net" with local phone access.
Services: A distance learning program that offers advanced placement courses to Vermont high schools has been developed by the University of Vermont.

VIRGINIA

Planning: Virginia's first six-year state technology plan was released in 1988. A second six-year plan was distributed for broad review in August 1995. Developed under the leadership of the Virginia Educational Technology Advisory Committee (VETAC), the focus areas are infrastructure, classroom and administrative technologies, teacher training and technical assistance, and evaluation. The plan is the blueprint for newly developed school

division plans in each of the 132 operating school divisions.

Infrastructure: The Department of Education operates a free K-12 data and information network known as Virginia's Public Education Network (PEN) and the Virginia Satellite Educational Network (VSEN), a distance learning network. Other infrastructure developments are complete or under development.

Funding: 1988-90 state funding to schools totaled $22.5 million for computers, distance learning, training, and software. 1994-95 state funding to schools totaled $69.5 million for library media centers including linkage to PEN and the Internet and LAN networking in each of 1,785 schools. Local share requirements to receive state funds added $1.6 million for teacher training. An unprecedented $75 million for 1996-97 has been proposed by the Governor for infrastructure, computers, networking, scientific probes, and graphing calculators to implement the recently adopted Standards of Learning. All state technology appropriations have utilized a composite index of ability to pay in order to address disparity.

WASHINGTON

Planning: Washington State's Technology Plan for K-12 Education released in September 1994 provides a vision, framework, and recommendations for 1995-97. Washington State's 1993 Education Reform Act mandated that a state technology plan for K-12 schools be developed as well as other initiatives, such as provisions for technology support to school districts through the Educational Technology Support Centers; enhancement of the statewide data network through the establishment of nine Internet hubs across the state; regional networking consultants; the establishment of the Washington Interactive Television system for video conferencing; and a one-time allocation of approximately $20.61 per student to districts for "instructional materials and technology related investments."

WEST VIRGINIA

Infrastructure: Bell Atlantic has invested $10 million in a project to connect every school to Internet services by 1996. The West Virginia Department of Education works cooperatively with the West Virginia Network for Educational Telecommunications to utilize existing telecommunications infrastructure.

Funding: Since October 1990, the Basic Skills/Computer Education Program has provided hardware and software for K-6 classrooms in the state to improve basic skills using technology. To date, nearly 17,500 student workstations have been placed in K-4 classrooms, over 4,375 classrooms have student utilization, and over 11,000 educators have been trained. Microsoft, in partnership with the West Virginia Department of Education, has donated $1.8 million worth of multimedia software. As of February 1996, the state has 50 technology demonstration sites, using advanced multimedia. It plans to increase the 320 satellite downlink sites. Through the Curriculum Technology Resource Center, West Virginia has 222 sites with complete turnkey laserdisc technology integration. In addition, 32 of those sites are multimedia sites. This year, the legislature allocated $1.8 million for specific telecommunications technology, and an additional State School Building Authority statewide grant of $2.1 million to assist with wiring.

WISCONSIN

Funding: A statewide "Advanced Telecommunications Foundation" has been established. Funding comes from telecommunications providers. The state has also funded a $10 million grant program that will enable schools and libraries to improve access to advanced telecommunications and distance education technologies. A 25 percent local match is required.

WYOMING

Planning: The Goals 2000 — Technology in Education Panel is in the initial stages of planning at the state level. Its intent is to have developed a technology plan for all educational entities in the state by May of 1997.

Infrastructure: Wyoming maintains a state network that currently reaches into nearly 20 communities.

Funding: As of spring of 1996, Wyoming had not designated any state dollars for technology in education.

APPENDIX D

Sources of Further Information

Getting Started: Sources of General Information

KickStart Initiative: Connecting America's Communities to the information superhighway. Final report of the National Information Infrastructure Advisory Council. This general report makes the case for what entire communities, not just schools, will gain from connecting to the information superhighway. It is packed with valuable information and examples from across the country. The report is available from the Benton Foundation, (202) 638-5770, and is available online at http://www.benton.org/KickStart/.

The Department of Education's Regional Technology in Education Consortia (R*TECs) provide advice and services free to states and school districts. There are six consortia, each serving a region of the country:

AK, WA, OR, ID, MT, WY: Northwest Regional Technology Consortium at (503) 275-9624. Contact: Seymour Hanflin, Director.

ND, SD, MN, IA, WI, IL, MI, IN: North Central Regional Technology Consortium, (708) 218-1272 or (708) 571-4700. Contact: Rafael Ramirez, Director.

OH, PA, MD, DC, NJ, DE, CT, RI, NY, VT, MA, NH, ME: Northeast Regional Technology Consortium, (212) 541-0972. Contact: Bonnie Brownstein, Co-Director.

CA, HI, NV, UT, AZ, CO, NM, Territories: Pacific/Southwest Regional Technology Consortium, (310) 985-1570. Contact: Kevin Rocap, Co-Director.

NE, KS, OK, TX, MO: South Central Regional Technology Consortium, (913) 864-4954. Contact: Jerry Chaffin or Ron Aust, Co-Directors.

AR, LA, MS, AL, GA, FL, SC, NC, VA, WV, KY, TN, PR, Virgin Islands: Southeast and Islands Regional Technology Consortium, (910) 334-3211. Contact: Jean Williams, Co-Director.

Plugging In: Choosing and Using Educational Technology. Available from the Council for Educational Development and Research, (202) 223-1593.

Connecting to the Future. A Guide for Building a Network Infrastructure for Education. A video and handbook developed by NASA and the National Center for Education Statistics, available from NASA CORE (216) 774-1051.

From Here to Technology: How to Fund Hardware, Software, and More. Available from the American Association of School Administrators, (703) 875-0748.

The International Society for Technology in Education (ISTE). ISTE represents computer-using teachers. Its catalog, "Resources and Services for Technology-Using Educators," is available free and lists products and services related to technology in schools. (800) 336-5191.

The National School Boards Association (NSBA) sells a variety of publications to help school and district administrators use technology effectively. A catalog is available by calling (800) 706-6722.

Government Resources On-Line

- U.S. Department of Education - http://www.ed.gov
  - http://www.ed.gov/Technology
- The White House - http://www.whitehouse.gov
  - http://www.whitehouse.gov/edtech.html
- The Library of Congress - http://lcweb.loc.gov
- Thomas (Information about the U.S. Congress) - http://thomas.loc.gov/
- The Supreme Court - http://www.law.cornell.edu/supct/
- FedWorld (Entry to government resources) - http://www.fedworld.gov
- U.S. Census Bureau Home Page - http://www.census.gov
- National Telecommunications and Information Administration - http://www.ntia.doc.gov
- Department of Defense Education Gateway - http://www.acq.osd.mil/ddre/edugate
- Department of Energy laboratories - http://www.doe.gov/html/servers/lablogos.html
- Department of Labor - Employment and Training Administration (ETA) http://www.doleta.gov/programs/programs.htm
- School to Work Opportunities - http://www.doleta.gov/programs/stw/stw.htm
- The Kennedy Center for the Performing Arts - ArtsEdge - http://artsedge.kennedy-center.org/
- National Aeronautics and Space Administration Educational Resources - http://quest.arc.nasa.gov/OER/
- NASA's K-12 Internet Initiative - http://quest.arc.nasa.gov/
- National Oceanic and Atmospheric Administration (NOAA) - gopher://gopher.esdim.noaa.gov/11/NOAA_systems/education/
- National Science Foundation - http://www.nsf.gov
- United States Geological Survey Education Resources - http://www.usgs.gov/education
- United States Information Agency Education and Cultural Exchanges - http://www.usia.gov/educatio.html

Department of Education Funded Projects On-Line

- National Regional Laboratories Home Page - http://www.nwrel.org/national/regional-labs.html
- Regional Technology Education Consortia - http://www.ed.gov/Technology

- Eisenhower National Clearinghouse for Mathematics and Science Education - http://www.enc.org
- National Clearinghouse for Bilingual Education - http://www.ncbe.gwu.edu
- Office of Special Education and Rehabilitative Services Regional Resources and Federal Centers - http://aed.org/special.ed/rrfc1.html
- Rehabilitation Engineering Research Center on Universal Telecommunications Access - http://fshb41.gallaudet.edu
- Assistive Technology Funding and Systems Change - http://www.asisttech.com/atfsc.html
- Rehabilitation Engineering Research Center on Adaptive Computers and Information Systems - http://trace.wisc.edu

Educational Resources Information Center (ERIC)

- Access ERIC - http://www.aspensys.com/eric2/welcome.html (also 1-800-LET-ERIC)
- AskERIC - http://ericir.sunsite.syr.edu/
- National Parent Information Network - http://ericps.ed.uiuc.edu/npin/npinhome.html
- ERIC Clearinghouse on Assessment and Evaluation - http://www.cua.edu/www/eric_ae
- ERIC Clearinghouse on Elementary and Early Childhood - http://ericps.ed.uiuc.edu/
- ERIC Clearinghouse on Information and Technology - Gopher://ericir.syr.edu:70/11/clearinghouses/16 houses/CIT
- ERIC Clearinghouse on Teaching and Teacher Education - http://www.erisp.org/
- ERIC Clearinghouse on Reading, English, and Communications - http://www.indiana.edu/~eric_rec
- ERIC Clearinghouse on Science, Mathematics, and Environmental Science - http://www.ericse.ohio-state.edu
- ERIC Clearinghouse on Social Studies and Social Science Education - http://www.indiana.edu/~ssdc/eric-chess.html
- ERIC Clearinghouse on Rural and Small Schools - http://www.ael.org/~eric/
- ERIC Clearinghouse on Urban Education - http://eric-web.tc.columbia.edu
- ERIC Clearinghouse on Disabilities and Gifted Education - http://www.cec.sped.org/erices

National Research and Development Centers

- Center for Research on Cultural Diversity and Second Language - http://zzyx.ucsc.edu/Cntr/cntr.html
- Center for Research on Educational Accountability and Teacher Evaluation (CREATE) - gopher://gopher.wmich.edu:70/11/wmu/evalctr/CREATE
- Center for Research on Evaluation, Standards, and Student Testing (CRESST) - http://www.cse.ucla.edu/CRESThome.html
- National Center on Adult Literacy - http://litserver.literacy.upenn.edu
- National Research Center on Student Learning - http://www.lrdc.pitt.edu/
- National Center for Research on Teacher Learning - gopher://burrow.cl.msu.edu:70/11/Internet/msu/ncrtl

Other On-Line Resources

- Education Associations and Organizations - http://www.ed.gov/EdRes/EdAssoc.html
- The Electronic Newsstand (online periodicals) - http://www.enews.com
- The Internet Public Library - http://ipl.sils.umich.edu
- Web66 (Link to school home pages) - http://web66.coled.umn.edu

Search Tools

If there are resources you need that are not listed here, go to one of the following sites to use a keyword search to locate it.

- InfoSeek - http://www.infoseek.com
- Lycos - http://lycos.cs.cmu.edu
- Yahoo - http://www.yahoo.com

CD ROM

family

community

history

reading

multimedia

software

math

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science

U.S. Department of Education
Washington, D.C. 20202
www.ed.gov
(800) USA-LEARN